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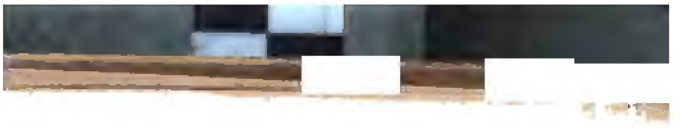

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EXECUTIVE DOCUMENTS

OF THE

HOUSE OF REPRESENTATIVES

FOR THE

THIRD SESSION OF THE FORTY-FIFTH CONGRESS,

1878-'79.

IN 18 VOLUMES.

VOLUME III.—REPORT OF THE CHIEF OF ENGINEERS, Part 1.

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REPORT

OF THE

SECRETARY OF WAR;

BEING PART OF

THE MESSAGE AND DOCUMENTS

COMMUNICATED TO THE

TWO HOUSES OF CONGRESS

AT THE

BEGINNING OF THE THIRD SESSION OF THE FORTY-FIFTH CONGRESS.

VOLUME II.
PART I.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1878.

REPORT

OF

THE CHIEF OF ENGINEERS.

REPORT

OF

THE CHIEF OF ENGINEERS.

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., October 19, 1878.

SIR: I have the honor to present for your information the following report upon the duties and operations of the Engineer Department for the fiscal year ending June 30, 1878:

OFFICERS OF THE CORPS OF ENGINEERS.

The number of officers holding commissions in the Corps of Engineers, United States Army, at the end of the fiscal year was 106 on the active list and 5 on the retired list, the latter, however, under the law of January 21, 1870, not being available for duty. In the duties devolving upon the corps by law and by its organization, the employment of a number of scientists and assistant engineers has been necessary.

Since last annual report the corps has lost by death two of its officers, Lieut. Col. John D. Kurtz, who died at Georgetown, D. C., October 16, 1877; and Capt. A. H. Burnham, who died at Lowell, Mass., September 12, 1877. One officer, First Lieut. Edgar W. Bass, resigned May 2, 1878, to accept appointment as professor of mathematics at the United States Military Academy.

There have been added to the corps, by promotion of graduates of the Military Academy, two second lieutenants, whose commissions date from June 15, 1878, but who did not become available for duty till after the close of the year, and are, therefore, not included in the strength of the corps.

On the 30th June, 1878, the officers were distributed as follows:

On duty, Office Chief of Engineers, including the chief	4
On duty, Office Chief of Engineers, Public Buildings and Grounds, District of Columbia	1
On duty, fortifications	3
On duty, fortifications and light-house duty	3
On duty, fortifications and river and harbor works	14
On duty, fortifications, river and harbor works, and light-house duty	4
On duty, river and harbor works	22
On duty, river and harbor works and light-house duty	5
On duty, survey Northern and Northwestern Lakes and Mississippi River	5
On duty, jetties at mouth of Mississippi River	1
On duty, explorations of country west of one hundredth meridian	5
On duty with battalion of engineers	11
On duty with battalion of engineers and fortifications	1
On duty with battalion of engineers and at Military Academy	2
On staffs of generals commanding divisions and departments and on river and harbor works	2
Detached on duty with the General of the Army, generals commanding divisions and departments, light-house establishment, Military Academy, Department of State, and the Board of Commissioners of the District of Columbia	19
On leave of absence	3
Suspended	1
Total	105

SEA-COAST AND LAKE-FRONTIER DEFENSES.

During the past fiscal year work upon our sea-coast defenses has been limited to operations for the care and preservation of the works only, no appropriations being available to continue to completion the batteries already begun.

The system to govern the future construction of our works was elaborated in 1869 and will be found stated in detail in Executive Document No. 271, House of Representatives, Forty-first Congress, second session, where it will be seen the system received the approval of the General of the Army and the Secretary of War, and since then has been repeatedly indorsed by the action of Congress.

The main features of this system are the use of heavy earthen barbette batteries, with parados and traverses, of heavy mortar batteries, and of obstructions in the channels (mainly electrical torpedoes) to hold vessels from running past the batteries and reaching the cities or depots beyond them. The modification of the casemates of our masonry forts was at that time deemed premature, it being then thought preferable to await the further development of iron-clad fleets and their armaments and to take advantage of the experience of foreign nations.

From 1869 to 1875, while appropriations for coast defense were granted by Congress, much progress was made in earthen barbette batteries for heavy guns and mortars; and further, a system of defense by torpedoes—a subject of continuous study up to this time—has been developed which only requires a sufficiency of material and trained men to put it into practice when needed. But torpedo defense, however efficient in itself, cannot stand alone; the torpedoes must be protected by shore batteries. Unfinished earthen batteries, however, provided with a small fraction only of the number of guns for which they were designed, and those of insufficient caliber, and mortar batteries without mortars, though aided by torpedoes, will form but a feeble defense against the powerful fleets prepared and now being prepared to take the high seas.

The great powers of Europe do not place their reliance on barbette batteries. They believe in, and are constructing, casemated forts, some of which are provided with wrought-iron scarps and others with iron casemate-shields to protect the gun, and gunners serving it, both from direct and curved fire. This department, while recommending and urging the construction of barbette batteries as an initiatory means of obtaining by comparatively small expenditures a partial defense for the numerous exposed harbors of our coast, has always insisted that the efficient service of the large guns mounted in them would require high parapets and depressing or counterpoise carriages. It has also, from the beginning, looked forward to the ultimate conversion of some of our casemated forts, which would admit the change, for the reception of guns of the largest caliber, and to the possible construction of new works. Within the past two years, in furtherance of these views, a large casemated fort has been designed to take the place of old Fort Lafayette at the Narrows entrance to New York Harbor. Plans also have been prepared for modifying the casemates of Fort Schuyler on the East River, and for completing Fort Carroll on the approaches to Baltimore. The modification of other casemated works is now a subject of study. It will require much time and large expenditures to make the foregoing modifications, and to complete our barbette and mortar batteries and furnish them with suitable armaments. It would be but an act of prudence to make the beginning without delay. The disasters of the first three months of a war under the present condition of our defenses might

cost the nation tenfold the expenditure that would be needed to thoroughly protect our coast against attack. Our great cities, New York, Philadelphia, Boston, San Francisco, New Orleans, Baltimore, and Washington, should they fall into the hands of an enemy, would suffer ten times more than the cost of all the forts necessary to secure them against such disaster. But such reverses would also be great calamities to the nation, crippling its war power.

When the great change in ships and their armaments was initiated, Great Britain did not hesitate to appropriate $40,000,000 for the defense of its most important harbors, and in addition she has already expended about $60,000,000 upon her iron-clad fleet. We may well profit by her example. There is nothing so costly to a nation as a lack of preparation for war. In fact, to be prepared for war will often prevent it; and though we may not feel the daily imminence of war with great foreign powers, as England did, yet with incomplete or inadequately armed defenses for our great sea-port cities, even the *attitude* of belligerency, which we not unfrequently have to assume, has not the imposing effect it should have, nor is it accompanied with a justly founded self-confidence on our own part. The neglect of suitable preparation cost France many millions of treasure, a portion of her territory, and a great humiliation. The same must inevitably happen to the United States if it does not push forward its coast defenses and provide them with guns like those possessed not only by the great powers, but even by smaller nations.

That our forts should be efficient we must have guns of power not inferior to those that will be brought to contend with them. These guns must have a protection—whether by earthen parapet and depressing carriage or by iron armor—no less efficient than that which protects the hostile gun.

Our system of torpedo defense must rely upon forts for protection, otherwise it would be rendered harmless. It would be speedily destroyed by an enemy if one of its iron-clad fleets were suffered to approach it unopposed. It is, therefore, by the combination of the two systems, viz, the torpedo defense and shore batteries, that our harbors can be made secure against the powerful iron-clads of the present day in the event of a war with a maritime nation.

It concerns the honor of the United States, when involved in controversy with other powers, to be able to appeal to the sword, but that appeal should be accompanied by the consciousness that the weapon appealed to would not be inferior to that held by the adversary. This relation of inferiority may at present exist though the adversary be a comparatively weaker power.

We have the assurance that iron plates can be manufactured in this country equal in magnitude and not inferior in quality to those which fifteen years of experience have enabled the English rolling-mills to turn out.

Congress has shown its interest in the material development of the resources of the country, and especially in reviving trade and relieving the working class, by liberal appropriations for river and harbor improvements. Might not the immediate undertaking, on an adequate scale, of the construction of efficient iron-clads, the manufacture of the so much needed guns of large caliber, and the now demanded renewal of revetment in iron of our most important sea-coast works, be not only a wise measure of national defense, but an incidental means of reopening our workshops and reviving one of our most important industries—the manufacture of iron?

It is believed that the present time, when all kinds of materials and

workmanship are depressed in value, when so many of our working population are unemployed, is particularly favorable to the work of perfecting our defenses and supplying them with guns equal in power with those which will be brought against them.

For detailed report upon the several works of fortification, I beg leave to refer to the synopsis of reports of the several officers in charge. The estimates for the works have been carefully revised by me and are earnestly recommended.

Special attention is invited to the estimate of $100,000 for torpedoes. The charges in the torpedoes are fired by the electrical current, and many parts of the system connot be obtained in an emergency. It is to procure and store such portions of the apparatus as cannot be speedily obtained in the event of sudden hostilities that the appropriation is asked.

Special attention is also asked to the item of $150,000 for preparing our most important forts for operating submarine mines by providing proper bomb-proof cover, galleries of approach, &c.; all these being essential to the successful operation of the torpedo system of defense, in connection with other works.

FORTIFICATIONS.

Fort Wayne, Michigan, in charge of Lieut. Col. C. E. Blunt, Corps of Engineers, until January 1, 1878; *since that date in charge of Major Walter McFarland, Corps of Engineers.*—This work commands the channel of Detroit River, and, with its exterior barbette batteries already planned, will control the navigation of that stream.

Nothing has been done to this work during the past year, and its condition is the same as at the close of the last annual report. No money has been expended upon it, and none is now asked for.

No appropriation was made for the fiscal year ending June 30, 1879.
No appropriation asked for next fiscal year.

Fort Porter, Black Rock, near Buffalo, N. Y., in charge of Lieut. Col. C. E. Blunt, Corps of Engineers, until January 1, 1878; *since that date in charge of Maj. Walter McFarland, Corps of Engineers.*—No change whatever has occurred in the condition of this work since the close of the last fiscal year. No money has been expended upon it, and no appropriation is asked for it.

No appropriation was made for the fiscal year ending June 30, 1879.
No appropriation asked for next fiscal year.

Fort Niagara, mouth of Niagara River, New York, in charge of Maj. Walter McFarland, Corps of Engineers.—This work is situated at the mouth of the Niagara River, commanding its *debouch* into Lake Ontario.

The condition of this work is essentially the same as it was at the close of the last fiscal year, the only work done being the taking down of the damaged masonry of the salient of the south bastion and its partial rebuilding.

No appropriation was made for the fiscal year ending June 30, 1879.
No appropriation asked for next fiscal year.

Fort Ontario, mouth of Oswego River, New York, in charge of Maj. Walter McFarland, Corps of Engineers.—This work protects the city of Oswego from a sudden attack or *coup de main*, or the levy of a contribution by a small force of an enemy on shipboard.

The condition of this work is the same as it was at the close of the last fiscal year, no money having been expended upon it except for hire of

watchman and minor repairs on the store-houses and workshops, and the temporary covering of one of the coal and wood vaults in the rampart in rear of one of the sets of officers' quarters.

No appropriation was made for the fiscal year ending June 30, 1879.
No appropriation asked for next fiscal year.

Fort Montgomery, outlet to Lake Champlain, New York, in charge of Capt. James Mercur, Corps of Engineers, until July 30, 1877; *since that date in charge of Col. Henry W. Benham, Corps of Engineers.*—This work occupies an important strategic point, and commands the entrance to Lake Champlain from the Richelieu or Saint John River.

The right or north face of Bastion D has been strengthened by large iron tie-rods, which appear to be required also on Curtain III; the work is otherwise in essentially the same condition as at the date of last report.

No appropriation was made for the fiscal year ending June 30, 1879.
No appropriation asked for next fiscal year.

Fort Knox, Bucksport, Penobscot River, Maine, in charge of Lieut. Col. J. C. Duane, Corps of Engineers.—This work, situated at the narrows of the Penobscot River, furnishes a defense for the city of Bangor, 18 miles above, and other towns bordering the river, and renders it available as a secure harbor of refuge for the shipping of the extensive eastern coast.

The condition of this work remains unchanged, no operations having been carried on during the fiscal year except for the necessary care and preservation of the property.

No appropriation was made for the fiscal year ending June 30, 1879.
No appropriation asked for next fiscal year.

Fort Popham, Kennebec River, Maine, in charge of Lieut. Col. J. C. Duane, Corps of Engineers.—This work defends the entrance through the mouth of the Kennebec River to the rich valley of this river, the cities of Bath and Augusta, and the United States arsenal at the latter place.

The condition of this work remains unchanged, no operations having been carried on during the fiscal year except for the necessary care and preservation of the property.

No appropriation was made for the fiscal year ending June 30, 1879.
No appropriation asked for next fiscal year.

Fort Gorges, Portland Harbor, Maine, in charge of Lieut. Col. J. C. Duane, Corps of Engineers.—This work is one of the series of forts designed to defend the harbor and channels leading into the harbor of the important strategic position occupied by the city of Portland.

The condition of this work remains unchanged, no operations having been carried on during the fiscal year except for the necessary care and preservation of the property.

No appropriation was made for the fiscal year ending June 30, 1879.
Appropriation asked for next fiscal year $10,000 00

Fort Preble, Portland Harbor, Maine, in charge of Lieut. Col. J. C. Duane, Corps of Engineers.—This work occupies such a position that three-fourths of its guns command the two principal channels entering the harbor of Portland.

The condition of this work remains unchanged, no operations having been carried on during the fiscal year except for the necessary care and preservation of the property.

No appropriation was made for the fiscal year ending June 30, 1879.
Appropriation asked for next fiscal year $30,000 00

Fort Scammel, Portland Harbor, Maine, in charge of Lieut. Col. J. C. Duane, Corps of Engineers.—This work occupies a very important position in the harbor and commands four of the channels leading into it.

The condition of this work remains unchanged, no operations having been carried on during the fiscal year except for the care and preservation of the property.

No appropriation was made for the fiscal year ending June 30, 1879.
Appropriation asked for next fiscal year $50,000 00

Battery on Portland Head, Portland Harbor, Maine, in charge of Lieut. Col. J. C. Duane, Corps of Engineers.—This work covers by its guns all the approaches to the main channel leading into the harbor, and will prevent by its fire an enemy's fleet from taking up, unopposed, a position behind Bangs's Island, from which to bombard Portland or shell the shipping in the harbor.

The condition of this work remains the same as at the close of the last fiscal year, no operations having been carried on except for the necessary care and preservation of the property.

No appropriation was made for the fiscal year ending June 30, 1879.
Appropriation asked for next fiscal year $50,000 00

Fort McClary, Portsmouth Harbor, New Hampshire, in charge of Lieut. Col. J. C. Duane, Corps of Engineers.—This work, together with Fort Constitution, opposite, forms the inner line of defense to the mouth of the Piscataqua River and to the navy-yard at Kittery, Me.

The condition of this work remains the same as at date of last report, no operations having been carried on except for the necessary care and preservation of the property.

No appropriation was made for the fiscal year ending June 30, 1879.
No appropriation asked for next fiscal year.

Fort Constitution, Portsmouth Harbor, New Hampshire, in charge of Lieut. Col. J. C. Duane, Corps of Engineers.—The condition of this work remains unchanged, no operations having been carried on except for the necessary care and preservation of the property.

No appropriation was made for the fiscal year ending June 30, 1879.
No appropriation asked for next fiscal year.

Battery on Gerrish's Island, Portsmouth Harbor, New Hampshire, in charge of Lieut. Col. J. C. Duane, Corps of Engineers.—This battery, with the one opposite, on Jerry's Point, forms the outer line of defense to Portsmouth Harbor and to the navy-yard at Kittery, Me.

This work remains the same as at the close of the last fiscal year, no operations having been carried on except for the necessary care and preservation of the property.

No appropriation was made for the fiscal year ending June 30, 1879.
Appropriation asked for next fiscal year $36,000 00

Battery on Jerry's Point, Portsmouth Harbor, New Hampshire, in charge of Lieut. Col. J. C. Duane, Corps of Engineers.—No operations were carried on at this work during the past fiscal year except for the necessary care and preservation of the property.

No appropriation was made for the fiscal year ending June 30, 1879.
Appropriation asked for next fiscal year $24,000 00

Fort Warren, Boston Harbor, Massachusetts, in charge of Col. Henry W. Benham, Corps of Engineers.—This important work is for the defense of the main channel of entrance to Boston Harbor, and commands the anchorage of Nantasket Roads.

This fort, without an appropriation for active operations during the year, remains essentially as by last report, with the exception of some

not as yet important injuries to the slopes and to the surface of the exposed, uncovered portions of the masonry of the bomb-proof traverses and magazines on the water-fronts of the main work. An appropriation would be very important for the completion of these unfinished works, so exposed to dilapidation as they were necessarily left by the failure of the funds for the two years past.

No appropriation was made for the fiscal year ending June 30, 1879.
Appropriation asked for next fiscal year..... $75,000 00

Battery at Long Island Head, Boston Harbor, Massachusetts, in charge of Col. Henry W. Benham, Corps of Engineers.—This work occupies an important position in the outer line of defense to Boston Harbor, and its guns bear upon all the channels of entrance thereto.

No work was done here for want of funds during the past year. The earth slopes and embankment, where much above the natural soil, have settled somewhat in parts, though not to any serious extent. The masonry of the breast-heights and magazines is all in good condition. The iron-work of the platforms needs repainting, and some repairs or protection to the wharf and shore-line adjacent is required. But this work may be delayed if there should be an early resumption of operations for the completion of this battery.

No appropriation was made for the fiscal year ending June 30, 1879.
Appropriation asked for next fiscal year..... $50,000 00

Fort Winthrop, Boston Harbor, Massachussetts, in charge of Col. Henry W. Benham, Corps of Engineers.—This is one of the works forming the inner line of defense to Boston Harbor and the navy-yard at Charlestown.

This work is essentially in the same condition as stated in last annual report. The batteries, drains, and slopes of the work are mostly advanced to near completion, and, with slight injuries occurring during the year, are mostly in fair condition.

But the necessities for the sea-walls, recommended for the protection of the east bluff of this island and on the south of the main work, are more and more apparent each year.

No appropriation was made for the fiscal year ending June 30, 1879.
Appropriation asked for next fiscal year..... $50,000 00

Fort Independence, Boston Harbor, Massachusetts, in charge of Col. Henry W. Benham, Corps of Engineers.—This is one of the works forming the inner line of defense for the harbor of Boston.

As from the want of funds no active operations were possible, this work remains essentially in the same condition as at the date of previous report. The slopes of parapets and magazines of the main work are in good condition, and, with the exception of some leaks in the casemate arches and some injuries to the unfinished slopes of the east exterior battery, the work as far as modified is in a good state of efficiency.

For continuing work on the exterior heavy-gun batteries, an appropriation is asked.

No appropriation was made for the fiscal year ending June 30, 1879.
Appropriation asked for next fiscal year..... $30,000 00

Fort at Clark's Point, New Bedford Harbor, Massachusetts, in charge of Maj. G. K. Warren, Corps of Engineers.—The guns of this work command the entrance of the harbor of New Bedford.

Nothing has been done during the past fiscal year except taking care of the property.

Plans for the heavy-gun batteries are ready, and work can be begun as soon as money is appropriated.

No appropriation was *made for the fiscal year ending June 30, 1879.*
Appropriation asked for next fiscal year $30,000 00

Fort Adams, Newport Harbor, Rhode Island, in charge of Maj. G. K. Warren, Corps of Engineers.—This large and important work defends the harbor and city of Newport, and commands the principal passage to Narragansett Bay, one of the best roadsteads on the coast.

During the fiscal year the fences have been extended so as to separate the new heavy water battery and the engineering buildings and property from the parts occupied for the ordinary purposes of the garrison.

The preparatory work for the construction of the new battery (such as opening roads, draining the grounds, &c.) having been all completed, rapid progress can be made in construction when the necessary funds are appropriated.

Many repairs are needed to the main work and to the permanent wharf.

No appropriation was made for the fiscal year ending June 30, 1879.
Appropriation asked for next fiscal year $40,000 00

Defenses of Dutch Island, western entrance to Narragansett Bay, Rhode Island, in charge of Maj. G. K. Warren, Corps of Engineers.—These defenses lie in and command the western passages to Narragansett Bay.

The only work performed during the fiscal year has been the general care of the property.

No other work is contemplated for the fiscal year ending June 30, 1879.

The appropriation asked for is for continuing the construction of the work.

No appropriation was made for the fiscal year ending June 30, 1879.
Appropriation asked for next fiscal year $40,000 00

Fort Trumbull, New London Harbor, Connecticut, in charge of Maj. J. W. Barlow, Corps of Engineers.—This work, upon the west bank of the Thames River, with Battery Griswold on the east bank, forms the defense of the harbor of New London.

Operations have been confined to the care and preservation of the work. The casemate arches of the west front have been examined to ascertain the cause of leakage; repointing the parade-wall has been commenced.

An appropriation for building the south exterior battery for heavy guns is recommended.

No appropriation was made for the fiscal year ending June 30, 1879.
Appropriation asked for next fiscal year $40,000 00

Fort Griswold, New London Harbor, Connecticut, in charge of Maj. J. W. Barlow, Corps of Engineers.—During the past fiscal year the inclosing walls have been repaired, and except the narrow strip communicating with the highway and river, the property is now fenced.

No appropriation was made for the fiscal year ending June 30, 1879.
No appropriation asked for next fiscal year.

Fort Hale, New Haven Harbor, Connecticut, in charge of Maj. J. W. Barlow, Corps of Engineers.—This works commands the channel entrance to New Haven Harbor. It was built during the late war for an immediate emergency, and was not intended to be permanent.

No work has been done during the past year.

A project to modify the sea front for modern ordnance, and to make permanent the bomb-proofs, at an estimated cost of $23,600, has been presented by the engineer officer in charge.

No appropriation was made for the fiscal year ending June 30, 1879.
No appropriation asked for next fiscal year.

Fort Schuyler, East River, New York, in charge of Maj. H. L. Abbot,

Corps of Engineers.—This is an important work for the defense of the entrance to the harbor of New York City through the East River.

Owing to the want of funds, nothing more than the ordinary care of the property has been possible during the past year.

The main work is in a state which urgently requires attention. The remodeling of the barbette tier, to enable it to receive its proposed armament of modern guns, has been mainly finished, but was suddenly stopped by the failure of the appropriation, and the new part now deteriorates under the action of the weather. This fact, and the vast importance of the work to the defense of New York Harbor, renders an appropriation specially needed.

A plan, which has been prepared for the modification of the casemates of three of the fronts to adapt them to the reception of the heaviest modern rifled ordnance behind iron shields, should be undertaken without delay, and a liberal appropriation for the same is urgently recommended.

No appropriation was made for the fiscal year ending June 30, 1879.
Appropriation asked for next fiscal year..... $150,000 00

Fort at Willets Point, eastern entrance to New York Harbor, in charge of Maj. H. L. Abbot, Corps of Engineers.—This work unites with Fort Schuyler in the defense of the entrance to the harbor of New York City through the East River.

Want of funds has prevented any essential progress in preparing this important position for use in defending New York City in case of war. In combination with Fort Schuyler it forms the sole defensive line upon which a hostile fleet, attempting to enter and shell the city, could be successfully opposed. To neglect the defensive works, while expending large sums upon improving the channel, as has been done for several years past, is to invite an overwhelming blow in the next war with a powerful maritime nation.

The following is a summary statement of work done for the preservation of the property during the past year:

In the middle battery about 2,702 cubic yards of earth have been placed in parapet, and all the sodding of the exterior slopes has been completed by placing 482 superficial yards of sod. In the east battery about 2,512 cubic yards of earth have been placed in parapet, and 2,769 superficial yards of exterior slopes and traverse magazine No. 13 have been sodded. Sea-wall in front of east battery has been extended 543 lineal feet. Storage casemates have been covered with 1,107 cubic yards of earth, and with 183 superficial yards of sodding on the exterior slope, and are completed. Galvanized iron pipes for carrying off the drainage from arches have been placed. The ordinary repairs of the different batteries and the care of the engineer property have consumed the rest of the funds available.

No appropriation was made for the fiscal year ending June 30, 1879.
Appropriation asked for next fiscal year..... $80,000 00

Fort Columbus, Governor's Island, New York Harbor, in charge of Capt. James Mercur, Corps of Engineers, until July 30, 1877; since that date in charge of Col. Henry W. Benham, Corps of Engineers.—No funds being available no work has been executed here during the past year, beyond some slight repairs and the general care of the slopes, &c., and the engineer property, the work remaining in essentially the same condition as at the date of last report.

In the last annual report estimates were made for an extension of the sea-wall on the west side of the island and for surface drains in the moat of Fort Columbus. The recommendations then made are repeated.

The shore-line along the southeast part of the island, back of the range of officers' quarters, between the south battery and the main wharves, is without protection and is irregularly broken down by the wash of the waves in storms, while in front, or outward from the shore, a shoal extends, bare at low water, to the distance of 100 feet to 200 feet, which, from its position in the eddy between the Buttermilk channel and the Hudson River, receives the drift and carrion offal of the river, making it often very offensive and injurious to the health of the residents on the island.

The best remedy for this, and a necessity, is considered to be a sea-wall of rounded or convex line of short faces, running out upon this shoal, which, without indentations, would give a regular current and direction to the water, thus tending to carry off all such offensive and deleterious matter, while the space in rear, filled up, as it might be without great cost, in part perhaps by the garrison, would add some acres to the area of the island, where every yard of land is so valuable. The construction of this wall is strongly urged by General W. S. Hancock, commanding Military Division of the Atlantic, and the medical authorities on the island.

The length of wall required would be about 1,800 running feet, and, if of 8 feet height, with stone facing and concrete backing and foundation, would cost, as near as can be estimated, about $20 per running foot, or $36,000. Adding for the wall on the west shore, the cost will be about $40,000.

The appropriation asked for is for the foregoing objects and for continuing the construction of the exterior battery for heavy ordnance.

No appropriation was made for the fiscal year ending June 30, 1879.
Appropriation asked for next fiscal year.....$75,000 00

Castle Williams, Governor's Island, New York Harbor, in charge of Capt. James Mercur, Corps of Engineers, until July 30, 1877; *since that date in charge of Col. Henry W. Benham, Corps of Engineers.*—No work was done here during the last fiscal year.

No appropriation was made for the fiscal year ending June 30, 1879.
No appropriation asked for next fiscal year.

South Battery, Governor's Island, New York Harbor, in charge of Capt. James Mercur, Corps of Engineers, until July 30, 1877; *since that date in charge of Col. Henry W. Benham, Corps of Engineers.*—No work was done here during the past fiscal year and none contemplated during the present.

No appropriation was made for the fiscal year ending June 30, 1879.
No appropriation asked for next fiscal year.

Fort Wood, Bedloe's Island, New York Harbor, in charge of Capt. James Mercur, Corps of Engineers, until July 30, 1877; *since that date in charge of Col. Henry W. Benham, Corps of Engineers.*—This work, together with those upon Governor's Island, is designed to close the entrance to the East and Hudson Rivers, and to cover New York, part of Brooklyn, and Jersey City from bombardment.

No funds were available and no operations undertaken during the past year. The defenses of the island, the quarters, and the buildings generally appear to be in fair condition, as at the date of the last annual report. The construction of a heavily armed water-battery is recommended by the Board of Engineers for Fortifications.

No appropriation was made for the fiscal year ending June 30, 1879.
No appropriation asked for next fiscal year.

Fort Hamilton and additional batteries, New York Harbor, in charge of

Capt. James Mercur, Corps of Engineers, until July 30, 1877; *since that date in charge of Col. Henry W. Benham, Corps of Engineers.*—These works are situated at the Narrows of New York Harbor, upon the Long Island side.

From want of funds no operations of importance have taken place here during the past year, and the work is essentially in the same condition as at the date of previous report. To meet, however, the cost of some repairs and additions to, or the completion of, batteries now in part constructed, an appropriation is recommended for the execution of this work during the coming fiscal year.

No appropriation was made for the fiscal year ending June 30, 1879.
Appropriation asked for next fiscal year..... $50,000 00

Mortar battery at Fort Hamilton, New York Harbor, in charge of Capt. James Mercur, Corps of Engineers, until July 30, 1877; *since that date in charge of Col. Henry W. Benham, Corps of Engineers.*—No operations were carried on during the past fiscal year.

Fort Lafayette, New York, harbor.—This old work, situated on a shoal at the Narrows entrance, occupies the best of all the positions for the defense of New York Harbor. It was injured by fire in December, 1868, to such a degree as to make it practically worthless unless repaired at a very considerable outlay; and as it was adapted to guns of small caliber only, it was not thought worth while to restore it, but to replace it by a new construction which should meet the demands of modern armaments.

A project for a casemated work has been, therefore, prepared, the estimated cost of which is $784,212, which shall admit of the mounting of 80 to 100 ton guns behind shields of iron. About one-half of the old work is utilized in this project for store-rooms, bomb-proof quarters, &c., while the remainder is an entirely new construction. It will require several years in building and should be undertaken without delay. An appropriation for its commencement is asked for next year.

No appropriation was made for the fiscal year ending June 30, 1879.
Appropriation asked for next fiscal year..... $200,000 00

Fort Wadsworth, Staten Island, New York Harbor, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—This fort, situated on the Staten Island side of the Narrows of New York Harbor, is a large casemated work, having its lower tier of guns only a few feet above the level of ordinary high water.

During the past fiscal year the iron work in the embrasures and the roofs of the store-rooms and guard-house have been painted.

The ditch requires cleaning out, some painting and pointing are needed, and shot-beds are wanted on the parade of the work. It is also very desirable that the reservoir of spring-water in the ditch of the work should be covered over, as it is becoming filled with a vegetable growth—probably a species of *bacteria*—which at times is carried into and chokes up the pipes, and may ultimately render the water unfit for domestic use. As this plant requires light for its generation and growth, it would doubtless disappear if the reservoir were covered.

No appropriation was made for the fiscal year ending June 30, 1879.
Appropriation asked for next fiscal year..... $9,000 00

Fort on site of Fort Tompkins, New York Harbor, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—This work crowns the hill in rear of Fort Wadsworth and the open batteries on Staten Island, and is designed to accommodate the garrisons and act as a keep for those works. When completed, it will be able to throw a heavy fire from a commanding position upon vessels attempting to pass through the Nar-

rows. It has been in readiness to receive its armament for some years. For want of funds, the operations during the past fiscal year have been restricted to repairs of the earthwork and roads damaged by storms, to cutting the grass on the slopes, constructing a masonry cesspool-trap at the foot of the interior slope of the cover-face and connecting it with the sewer leading to the river, keeping a supply of water in the distributing reservoir located on the glacis, and other necessary minor repairs.

No operations can be carried on during the present fiscal year for want of funds.

Attention has been called in former reports to the bad condition of the large slope in front of the channel face of this work, and an appropriation for completing it is again earnestly recommended.

Amount (estimated) required for completing Fort Tompkins, the glacis gun-battery, and the North and South Cliff batteries, $175,000.

No appropriation was made for the fiscal year ending June 30, 1879.
Appropriation asked for next fiscal year..... $75,000 00

Glacis Gun Battery (north of fort on site of Fort Tompkins), Staten Island, New York Harbor, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—This battery has been in readiness to receive its armament for the last four years. Some little work yet remains to be done to the magazine-doors and lamp-closets. No work was done during the last fiscal year except to cut the grass from the slopes and repair minor damages to the same.

The cost of substituting stone for timber platforms, amounting to about $9,000, is included in the estimate for Fort Tompkins.

No separate appropriation asked for this work.

Glacis Mortar Battery (south of fort on site of Fort Tompkins), Staten Island, New York Harbor, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—This battery and its armament are ready for service. A little work yet remains to be done upon the lamp-closets, and the principal magazine requires to be furred off. No work was done during the last fiscal year except cutting the grass from the slopes.

An appropriation for next fiscal year is asked for in the estimates under the head of sea-coast mortar batteries.

Battery Hudson, Staten Island, New York Harbor , in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—This work and the North Cliff and South Cliff batteries occupy the slope between Fort Tompkins and the water, and are able to bring a powerful fire upon the channel leading up to and through the Narrows.

During the last fiscal year the earthen slopes have been kept well dressed and in a tolerably good state of preservation. A wrought-iron clamp 6″ by 10″ has been fitted around the granite pintle-block in the platform of King's counterpoise carriage.

The estimate for the completion of this work contemplates substituting stone for the existing wooden platforms and the construction of bonnets upon the traverses.

Amount (estimated) required for completing the work, $36,199.00

No appropriation was made for the fiscal year ending June 30, 1879.
Appropriation asked for next fiscal year..... $24,000 00

South Mortar Battery (in rear of Battery Hudson extension), Staten Island, New York Harbor, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—The work necessary for the completion of this battery consists in constructing and laying eight timber mortar-platforms upon concrete

foundations, now in place, in fitting up the inner magazine doors and two lamp-closets. No platforms are finished.

No appropriation was made for the fiscal year ending June 30, 1879.
An appropriation for next fiscal year is asked for in the estimates under the head of sea-coast mortar batteries.

North Cliff Battery, Staten Island, New York Harbor, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—A dry stone drain sixty feet in length was built in the rear slope at the north end of the battery, and a portion of the slope was regraded and sodded.

The cost of completing the battery, by substituting six stone gun-platforms for those of timber, constructing six stone breast-height walls, two bonnets on the traverses, lining the two principal magazines with timber, thickening the parapet, and constructing a rough sea-wall at the foot of the exterior slope, amounting in the aggregate to $34,700, is included in the estimate for fort on site of Fort Tompkins.

No separate appropriation asked for next fiscal year.

South Cliff Battery, Staten Island, New York harbor, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—With the exception of slight repairs to the slopes, cutting the grass, &c., no work was done in this battery during the past fiscal year for want of funds. There has been no change in the armament during the year.

The cost of completing the battery in accordance with the approved plan, including the thickening of the parapet, a rough sea-wall at the foot of the exterior slope, and wooden linings in the principal magazines, amounting in the whole to $37,100, is included in the estimate for fort on site of Fort Tompkins.

No separate appropriation is asked for next fiscal year.

Fort at Sandy Hook, New Jersey, in charge of Capt. James Mercur, Corps of Engineers, until July 30, 1877; *since that date in charge of Col. Henry W. Benham, Corps of Engineers.*—One of the great objects of this work is to prevent the occupation of the lower bay as an anchorage by an enemy's fleets.

No funds having been available no work has been done upon this fort during the past year. This work remains in the condition in which it has been for several years past, that is, with the lower tier of casemates essentially completed upon the north, the east, and the west fronts, providing positions for about 100 guns. Some work has been executed for the protection of the site against the dangers of the ocean storms upon the east of the fort, and a sand-box bulk-head has been constructed here for nearly 1,300 feet along the line of shore which connects the four or five jetties in front, which it is hoped will give the necessary protection against further encroachment of the ocean upon this position.

An appropriation for the needful protection of the site is recommended.

No appropriation was made for the fiscal year ending June 30, 1879.
Appropriation asked for next fiscal year..... $10,000 00

Fort Mifflin, Delaware River, Pennsylvania, in charge of Lieut. Col. J. D. Kurtz, Corps of Engineers, until his death, October 16, 1877; *temporarily in charge of Capt. William Ludlow, Corps of Engineers, until December* 1, 1877; *since that date in charge of Col. J. N. Macomb, Corps of Engineers.*—This fort constitutes one of the inner line of works for the defense of Philadelphia and the naval establishment at League Island.

Except making requisite repairs to the dike on river front, stone coping at main sluice, buildings, one small bridge, water-tanks, and cutting

the grass, the condition of the work remains the same as at the close of the previous fiscal year.

No appropriation having been made for the present fiscal year, the work will continue under the immediate care of a fort-keeper.

During the next fiscal year it is proposed to construct the torpedo casemate-gallery, complete the exterior battery, construct battery on north face of demilune and on south face main work, commence construction of storage-magazine at exterior battery, and make necessary repairs to dikes, roads, &c.

No appropriation was made for the fiscal year ending June 30, 1879.
Appropriation asked for next fiscal year..... $75,000 00

Mortar battery at Fort Mifflin, Delaware River, Pennsylvania, in charge of Lieut. Col. J. D. Kurtz, Corps of Engineers, until his death, October 16, 1877; *temporarily in charge of Capt. William Ludlow, Corps of Engineers, until December* 1, 1877; *since that date in charge of Col. J. N. Macomb, Corps of Engineers.*—Work on this battery remains suspended for want of funds, for which reason no work is proposed for the present fiscal year.

An appropriation of $20,000 for continuing this work is included under the head of sea-coast mortar batteries.

No appropriation was made for the fiscal year ending June 30, 1879.
No separate appropriation asked for next fiscal year.

Site for the defenses at Red Bank, New Jersey, in charge of Lieut. Col. J. D. Kurtz, Corps of Engineers, until his death, October 16, 1877; *temporarily in charge of Capt. William Ludlow, Corps of Engineers, until December* 1, 1877; *since that date in charge of Col. J. N. Macomb, Corps of Engineers.*—This site is upon the New Jersey side of the Delaware River, nearly opposite Fort Mifflin, and is in care of a property-keeper.

During the past year requisite repairs have been made to the dike along the Delaware River front and to the buildings.

It is proposed during the present year to strengthen the dike on the Delaware River front and make necessary repairs to the buildings and fences, and exercise the usual care over the site and other public property.

No appropriation has yet been made for a battery on this site.
No appropriation asked for next fiscal year.

Fort Delaware, Delaware River, Delaware, in charge of Lieut. Col. J. D. Kurtz, Corps of Engineers, until his death, October 16, 1877; *temporarily in charge of Capt. William Ludlow, Corps of Engineers, until December* 1, 1877; *since that date in charge of Col. J. N. Macomb, Corps of Engineers.*—This work, situated on the Pea Patch Island, forms one of the chain of works constituting the outer line of defense for the Delaware River.

Operations during the year have been confined to the care and preservation of public property. Slight repairs have been made to the dike and to the southern wharf.

The condition of the fort remains about the same as last year, and there has been no change in armament.

An appropriation for next year is asked to be applied to the construction of a torpedo-casemate, to increasing the thickness of walls of magazine to protect them against the fire of modern heavy ordnance, to completing the permanent wharf and the repair of the temporary ones, and to the repair of buildings, dikes, &c.

No appropriation was made for the fiscal year ending June 30, 1879.
Appropriation asked for next fiscal year $75,000 00

Battery at Finn's Point, Delaware River, New Jersey, in charge of Lieut. Col. J. D. Kurtz, Corps of Engineers, until his death, October 16, 1877; *temporarily in charge of Capt. William Ludlow, Corps of Engineers, until December* 1, 1877; *since that date in charge of Col. J. N. Macomb, Corps of Engineers.*—This is a powerful earthen barbette battery, and forms the left of the outer line of defenses across the mouth of the Delaware River.

The condition of the battery remains the same as at the date of last report. A part of the breast-height wall has been repointed and the revetment above it has been reformed and sodded. The dike on the river front has been kept in serviceable condition by occasional repairs.

For continuing the work an appropriation is asked for next year.

No appropriation was made for the fiscal year ending June 30, 1879.
Appropriation asked for next fiscal year $50,000 00

Mortar battery at Finn's Point, Delaware River, New Jersey, in charge of Lieut. Col. J. D. Kurtz, Corps of Engineers, until his death, October 16, 1877; *temporarily in charge of Capt. William Ludlow, Corps of Engineers, until December* 1, 1877; *since that date in charge of Col. J. N. Macomb, Corps of Engineers.*—No operations were carried on at this work during the past year for want of funds, and none are contemplated for the present year.

The sea-wall supporting the exterior slope has been damaged by storms, and the unfinished embankment has been washed away to some extent.

An appropriation of $25,000 to complete this work is asked for under the head of sea-coast mortar batteries.

No appropriation was made for the fiscal year ending June 30, 1879.
No separate appropriation asked for next fiscal year.

Fort opposite Fort Delaware, Delaware shore, in charge of Lieut. Col. J. D. Kurtz, Corps of Engineers, until his death, October 16, 1877; *temporarily in charge of Capt. William Ludlow, Corps of Engineers, until December* 1, 1877; *since that date in charge of Col. J. N. Macomb, Corps of Engineers.*—A strong earthen barbette battery, forming the right of the outer line of defenses for the Delaware River.

Up to November, 1877, the dike on the river front was kept in serviceable condition by frequent repairs, but by a severe storm on the 24th of that month the top was entirely swept away, rendering further repairs useless, short of rebuilding the top for nearly the whole length.

The condition of the battery is the same as last year, no work beyond that necessary for the care and preservation of public property having been done.

For continuing the construction of this unfinished work, an appropriation for next year is recommended.

No appropriation was made for the fiscal year ending June 30, 1879.
Appropriation asked for next fiscal year $75,000 00

Mortar battery near Delaware City, Delaware, in charge of Lieut. Col. J. D. Kurtz, Corps of Engineers, until his death, October 16, 1877; *temporarily in charge of Capt. William Ludlow, Corps of Engineers, until December* 1, 1877; *since that date in charge of Col. J. N. Macomb, Corps of Engineers.*—No work has been done at this battery during the year for want of funds.

The work necessary for completion consists in the construction of the large magazine on the right, the completion of the parapet and traverses, and the building of six mortar-platforms. For these objects an ap-

propriation of $18,000 for next year is included in the estimates under the head of sea-coast mortar batteries.

No appropriation was made for the fiscal year ending June 30, 1879.
No separate appropriation asked for next fiscal year.

Fort McHenry, Baltimore Harbor, Maryland, in charge of Maj. William P. Craighill, Corps of Engineers, until March 26, 1878; *since that date temporarily in charge of Capt. Charles B. Phillips, Corps of Engineers.*—This fort forms part of the inner line of defense for Baltimore and its dependent interests, and commands, with its fire, the interior waters of the harbor and the channel of approach thereto, in which latter a depth of 24 feet exists at mean low water.

Although the old fort (proper) has become almost useless as a defensive work, the site is still an important one, and the water front should be occupied by a battery of heavy guns, mounted behind a sand parapet of the most approved model, and provided with bomb-proof cover for ammunition and gunners. Such a battery is in course of construction, although all work upon same has, for want of funds, been suspended since July 8, 1876. The condition in which this battery stood at the above date is given in the last annual report.

There being no appropriation for the fiscal year ending June 30, 1878, operations have been confined to the general care and preservation of the work. In July, 1877, the slopes of the exterior battery and other outworks were carefully mown. In September, 1877, slight repairs were made upon the slate roof of the large exterior magazine. In February, 1878, transportation was afforded for about 7,000 bushels of oyster shells, which were used as a top-dressing for roads and walks, under the direction of the post commander.

During the months of April and May last, the slopes of the demilune of main work were repaired, as well as the exterior slope of the new water battery. Thirty square yards of resodding were done at the latter-mentioned point, where a land-slip had occurred. During May last three double wooden doors for magazines at main work were constructed and put in place.

All the portable property pertaining to the work has remained stored at Fort Carroll.

The sum of $50,000 is asked for the next fiscal year, which amount would nearly complete the parapet and terre-plein, including magazines, but not the gun-platforms, which, as stated in previous reports, it is not deemed advisable to put down until after the embankments shall have become consolidated, on account of the unstable nature of the subsoil.

No appropriation was made for the fiscal year ending June 30, 1879.
Appropriation asked for next fiscal year..... $50,000 00

Fort Carroll, Baltimore Harbor, Maryland, in charge of Maj. William P. Craighill, Corps of Engineers, until March 26, 1878; *since that date temporarily in charge of Capt. Charles B. Phillips, Corps of Engineers.*—This fort is situated upon an exterior line of defense for the harbor of Baltimore.

Nothing has been done in the past year in carrying out the project for its completion, which contemplated the provision for three tiers of guns in casemates and one in barbette.

The site is a very important one, and the delay in the construction of the work is due to the lack of appropriations, and to the fact that the best method of arranging such defenses, with a due regard to economy, has not till recently been determined.

Operations during the past year have been confined to the general

care and preservation of the work and the public property stored at this point.

Quite severe storms occurred during the months of July, October, and November, 1877, and considerable damage was done thereby to the temporary wooden roofs over unfinished casemates. These damages were promptly repaired at no great expense, as most of the old material was made use of.

The storm of October last broke up the wooden cover in front of the 15″ gun at angle 5-6, and also removed the oaken fender-pieces at the stone wharf at entrance to fort.

The gun-cover was immediately repaired and the broken fenders replaced.

Since November last no repairs have been necessitated, and the entire work and property in store has remained secure.

A plan for the completion of this work has been prepared, which provides for the reception of the heaviest modern rifled guns; those in casemates to be arranged in a single tier behind iron shields, and those in barbette to be placed singly between traverses, behind earthen parapets. An appropriation for the continuation of the work according to this plan is urgently recommended.

The portable property belonging to Fort McHenry is stored at this point.

No appropriation was made for the fiscal year ending June 30, 1879.
Appropriation asked for next fiscal year..... $100,000 00

Obstructions of the Potomac, in charge of Maj. William P. Craighill, Corps of Engineers, until March 26, 1878; *since that date temporarily in charge of Capt. Charles B. Phillips, Corps of Engineers.*—The material pertaining to these obstructions has continued in store at Fort Foote, in charge of a watchman. The timber portion of it has become very much decayed, and is rapidly becoming worthless. The pile foundation of the building in which these obstructions are stored was repaired in the fall of 1876. The building has since remained in very good condition.

Fort Foote, Potomac River, Maryland, in charge of Maj. William P. Craighill, Corps of Engineers, until March 26, 1878; *since that date temporarily in charge of Capt. Charles B. Phillips, Corps of Engineers.*—This work is on the inner line of defense of the channel of approach by water to Alexandria, Washington, and Georgetown. The site is high, commanding, and unusually favorable.

During the past fiscal year, for want of funds, no work was done beyond what was necessary for the preservation of the work and the public property in store.

Attention is again urgently called to the fact that the fort in its present unfinished condition is daily becoming deteriorated. To care for the work already done, the modification of the main fort should be completed as soon as possible.

An appropriation for this purpose is very important.

No appropriation was made for the fiscal year ending June 30, 1879.
Appropriation asked for next fiscal year..... $50,000 00

Fort Washington, Potomac River, Maryland, in charge of Maj. William P. Craighill, Corps of Engineers, until March 26, 1878; *since that date temporarily in charge of Capt. Charles B. Phillips, Corps of Engineers.*—This fort occupies a very important position on the outer line of defense of the cities of Alexandria, Washington, and Georgetown, and their dependent interests. The importance of *this site has* been fully set forth in previous annual *reports; but the line requires* strengthening by the

introduction of guns of the heaviest caliber, for which the old fort is not well adapted.

A revised project of defense for this site has been prepared by the Board of Engineers for Fortifications.

As there has been no specific appropriation for this work, operations during the past fiscal year have been confined to the general care and preservation of the public property in store and to such repairs as were absolutely necessary.

In December, 1877, the slate roofs of the two principal magazines in the main work were put in thorough repair, as was also the shingle roof of the adjutant's office at the main entrance.

A severe storm during the early part of October last caused considerable damage to the northern face of the wharf. This face was badly broken up for a distance of 200 feet and to about 5 feet below the top of the wharf, and the earth backing was removed to a distance of from 10 to 12 feet from the face.

Subsequent storms increased the amount of damage until it became absolutely necessary to make repairs in order to preserve the rest of the wharf. These repairs were made during the month of June last, and although not as complete as desired, were yet sufficient to check further deterioration. Eleven hundred and forty-five linear feet of white-oak timber were used, and 140 cubic yards of earth filling were replaced.

Attention is again earnestly invited to the need of the appropriation asked for this fort. The unfinished portion of the work is constantly suffering deterioration on account of its incomplete state.

No appropriation was made for the fiscal year ending June 30, 1879.
Appropriation asked for next fiscal year $50,000 00

Fort Monroe, Old Point Comfort, Virginia, temporarily in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—This extensive work occupies an important position, covering the approach to Hampton Roads, the navy-yard at Portsmouth, and the James River.

During the past fiscal year the planking of the bridges across the moat on the north and east fronts has been renewed and slight repairs were made to the breakwater opposite fronts 2 and 3.

A timber 13-inch sea-coast mortar platform was laid in rear of the 15-inch gun battery in the salient of the covered way, fronts 4 and 5.

For continuing the modifications of the channel-bearing faces of this work to adapt them to the reception of modern guns of heavy caliber, an appropriation for next year is recommended.

No appropriation was made for the fiscal year ending June 30, 1879.
Appropriation asked for next fiscal year $75,000 00

Artesian well at Fort Monroe, Virginia, temporarily in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—No work was done during the last fiscal year, and none is contemplated during the present fiscal year for want of funds. The inadequate and uncertain supply of water at Fort Monroe is an evil which, it is conceded on all sides, may at any time arise to serious magnitude. The present depth of the well is about 900 feet. It is recommended that provision be made to increase this depth to 1,200, or even to 1,500 feet, before abandoning the project of obtaining a water-supply by this method.

No appropriation was made for the fiscal year ending June 30, 1879.
Appropriation asked for next fiscal year $10,000 00

Fort Wool, Hampton Roads, Virginia, temporarily in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—This casemated fortification unites with Fort Monroe in closing the passage to Hampton Roads, *crossing its fire with the guns* of that fort.

Until approved projects for its completion are devised no further work is contemplated than is necessary to preserve it from injury. Fifty-two iron-throated casemates of the first tier are ready for guns, and in an emergency several 15-inch guns could be advantageously and promptly mounted in barbette.

No appropriation was made for the fiscal year ending June 30, 1879.
No appropriation asked for next fiscal year.

Fort Macon, Beaufort Harbor, North Carolina, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—This work is situated at the mouth of the harbor, and defends the principal entrance thereto.

The subject of the modification of this work is still under consideration.

During the past fiscal year monthly measurements have been made of the position of the shore-line in the vicinity of the wharf. These show that the high-water line has moved in from 100 to 150 feet at a point a little north of east of the fort since June, 1877, and between 250 and 300 feet since June, 1876. Should this movement continue, the construction of one or more jetties north of those at present existing may become necessary to protect the site of the fort.

No material changes have occurred in the shore-line south of the fort.

No appropriation was made for the fiscal year ending June 30, 1879.
No appropriation asked for next fiscal year.

Fort Caswell, mouth of Cape Fear River, North Carolina, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—The subject of the modification of this work is still under consideration.

Its location is advantageous for the protection of one of the entrances to Cape Fear River, and therefore one of the approaches to the city of Wilmington.

There is neither armament nor garrison, nor quarters for a garrison, at the place.

No appropriation was made for the fiscal year ending June 30, 1879.
No appropriation asked for next fiscal year.

Fort Moultrie, Charleston Harbor, South Carolina, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—This work is situated on Sullivan Island, and defends the principal entrance to the harbor of Charleston.

No work was done during the last fiscal year, except for the general preservation and repair of the work.

Two 15-inch guns are mounted on timber platforms, and eight platforms, one permanent and seven timber, are in readiness for, but not occupied by, heavy guns. Two additional timber platforms for 10-inch guns have become unserviceable from decay. The replacing of these with two timber 15-inch-gun platforms, now on hand, will complete the preparations for arming this work.

Four mortars are mounted in rear of the fort.

Estimated cost of completing the work (including bonnets on the traverses, a soldiers' latrine, and draining the parade), $89,000.

No appropriation was made for the fiscal year ending June 30, 1879.
Appropriation asked for next fiscal year..... $50,000 00

Fort Sumter, Charleston Harbor, South Carolina, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—This work is located on a shoal near the mouth of the harbor, and its guns, crossing their fire with those of Fort Moultrie, command the principal channel of entrance thereto.

During the past fiscal year an extension, 30 feet long and 12½ feet wide,

was built to the north end of the wharf. No other operations were carried on for want of funds.

The slopes to the terre-pleins of the north and northeast fronts have been badly washed by heavy storms.

Two 15-inch guns and two 300-pounder Parrott rifles are mounted on 15-inch timber platforms, and one timber and three permanent platforms for heavy guns are ready, but not occupied. The replacing of the two platforms 9 and 10, now occupied by light guns, by heavy timber platforms would make the work ready for its armament. The 11 casemates on northwest front are now ready for their guns, except traverse-circles.

The estimated cost of completing the work is $52,000.

No appropriation was made for the fiscal year ending June 30, 1879.
Appropriation asked for next fiscal year..... $50,000 00

Fort Johnson, Charleston Harbor, South Carolina, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—This fort, situated on James Island, is one of the works in the system of defense of Charleston Harbor.

No operations were carried on at this work during the past fiscal year. The approved project for reconstructing this old work contemplates making of it a battery for eight pieces of heavy ordnance, four mortars, and four guns. Its commencement and completion, during the next fiscal year, is recommended. Four 13-inch mortar-platforms are on hand, ready to be laid.

No appropriation was made for the fiscal year ending June 30, 1879.
Appropriation asked for next fiscal year..... $10,000 00

Castle Pinckney, Charleston Harbor, South Carolina, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—This work, situated on an island near the city of Charleston, is one of the interior works in the system of defense of the harbor.

No operations were carried on at this work during the past fiscal year. An appropriation of $9,500 will be required to adapt it to the reception of 10-inch smooth-bore guns or corresponding rifles, to be mounted in barbette.

No appropriation was made for the fiscal year ending June 30, 1879.
No appropriation asked for next fiscal year.

Fort Jackson, Savannah River, Georgia, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—This work, situated about four miles from the city of Savannah, forms the inner line of defense for that city.

No operations were carried on during the past fiscal year. Five guns are in position, but they are not of the calibers contemplated in the approved project, and cannot be efficiently served without a completion of the work. Estimated cost of completing the work, including repairs to wharf, $10,000.

No appropriation was made for the fiscal year ending June 30, 1879.
Appropriation asked for next fiscal year..... $10,000 00

Fort Pulaski, mouth of Savannah River, Georgia, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—This is the principal work for the defense of Savannah on the outer line of the system.

No operations were carried on at this work during the last fiscal year, except the cleaning out of the drains in the vicinity of the fort and cutting the grass from the slopes. Five timber platforms are now in readiness for, but not occupied by, heavy guns in the demilune.

Estimated cost of completing the work, including bonnets on the traverses, permanent platforms, and soldiers' latrine, $256,000.

No appropriation was made for the fiscal year ending June 30, 1879.
Appropriation asked for next fiscal year..... $75,000 00

New Fort on Tybee Island, mouth of Savannah River, Georgia, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—Plans for the defensive works to be constructed on the north point of Tybee Island have been completed, and it is proposed to commence their construction whenever funds are available.

Estimated cost of the works, $294,918.

No appropriation for their construction has yet been made.
No appropriation asked for next fiscal year.

Fort Clinch, Amelia Island, Florida, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—This work defends the entrance into Cumberland Sound, and is in an unfinished condition.

No operations have been carried on during the year, the project for the modification of the work being still under consideration.

No appropriation was made for the fiscal year ending June 30, 1879.
No appropriation asked for next fiscal year.

Fort Marion, Saint Augustine, Fla., in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—This work defends the harbor and city of Saint Augustine.

Fort Marion was built by the Spaniards, and was called by them Fort Saint Mark. It was essentially completed in the year 1756, its process of construction having extended through a period of more than one hundred years. It is built of coquina—a natural shell-concrete found in the vicinity. No money has been expended by the United States for the maintenance of the work, or in arresting the progress of ordinary deterioration and decay, for the reason, doubtless, that the water-battery, constructed in 1842–'43, will, if suitably armed, furnish a sufficient defense for this locality.

Should it be desired to restore old Fort Saint Mark—both main work and demilune—to the condition, substantially, in which it was left by the Spaniards, it can be done, so far as it is possible to attain this object, and omitting all preparations for an armament, for from $10,000 to $12,000.

No appropriation is asked for this work.

Fort Taylor and batteries, Key West, Florida, in charge of Capt. W. H. Heuer, Corps of Engineers.—This work is for the defense of the important harbor of Key West.

During the past fiscal year, operations were restricted to caring for the public property and buildings.

For certain necessary repairs to the main work and buildings, for repairing bridge connecting the fort with the island of Key West, and for continuing the construction of the exterior batteries for modern guns of large caliber, an appropriation is recommended.

No appropriation was made for the fiscal year ending June 30, 1879.
Appropriation asked for next fiscal year..... $75,000 00

Fort Jefferson, Garden Key, Tortugas, Florida, in charge of Capt. W. H. Heuer, Corps of Engineers.—The guns of this work perfectly command the admirable harbor lying in the heart of this group of keys.

During the year the quarters and barracks within the fort were repaired, kitchens reroofed, sewers cleaned, and bridge over ditch rebuilt. The embrasures were all scraped and painted.

For needful repairs to the work an appropriation for next year is recommended.

No appropriation was made for fiscal year ending June 30, 1879.
Appropriation asked for next fiscal year..... $28,000 00

Fort Pickens, Pensacola Harbor, Florida, in charge of Capt. A. N. Damrell, Corps of Engineers.—This work, with Fort Barrancas, and the proposed new batteries near the site of Fort McRee, constitute the defenses to the town and harbor of Pensacola, and to the navy-yard at Warrington.

Operations during the year were confined to necessary repairs of buildings and slight repairs to wharf damaged by a storm in October, 1877.

The condition of the fort is the same as at the date of last annual report.

Operations during the present fiscal year will be confined to ordinary repairs, and care and preservation of public property.

No appropriation was made for the fiscal year ending June 30, 1879.
Appropriation asked for next fiscal year $75,000 00

Fort Barrancas and redoubt, Pensacola Harbor, Florida, in charge of Capt. A. N. Damrell, Corps of Engineers.—No changes have been made in this work during the last fiscal year, with the exception of repairs to bridge and stairs in the fort.

No appropriation was made for fiscal year ending June 30, 1879.
No appropriation asked for next fiscal year.

Fort McRee, Pensacola Harbor, Florida, in charge of Capt. A. N. Damrell, Corps of Engineers.—The greater portion of this fort has been since the war a ruin, having been thrown down by the encroachment of the sea. All property worth moving has been transferred to Fort Pickens, Florida.

No appropriation was made for the fiscal year ending June 30, 1879.
Appropriation asked for next fiscal year $50,000 00

Fort Morgan, eastern entrance to Mobile Bay, Alabama, in charge of Capt. A. N. Damrell, Corps of Engineers.—This work, with Fort Gaines on the western side of the entrance, forms the outer line of defense to the harbor and city of Mobile.

The extension of the sea-wall, referred to in last annual report, was completed March 13, 1878. It is 750 feet long. In its construction 1,125 cubic yards of concrete and 592 cubic yards of brick masonry were required; 1,477 cubic yards of sand were excavated from the foundation, and 7,500 cubic yards of sand were hauled for back-filling. The amount of work, and consequently the cost, were considerably increased by damage done by a hurricane on the 1st and 2d of October.

The quarters required for use were repaired and painted. The boat-house, destroyed by the October storm, was rebuilt. Two brick cisterns with capacity of 7,300 gallons each, for supplying workmen with good water, were built, one at each end of the mess-hall, and the necessary conductors put upon the building.

No special appropriation having been made for this fort for the next fiscal year, operations will be confined to ordinary repairs to fort, buildings, and wharf, and care of public property.

For modification of the work to admit of the mounting of modern heavy ordnance an appropriation is asked for next year.

No appropriation was made for the fiscal year ending June 30, 1879.
Appropriation asked for next fiscal year $75,000 00

Fort Gaines, Dauphin Island, Mobile Bay, Alabama, in charge of Capt. A. N. Damrell, Corps of Engineers.—Operations during the year were confined to necessary repairs to quarters.

The condition of this fort is the same as at the date of last annual report.

For modifying this work to adapt it to a heavier armament than can now be mounted, an appropriation for next year is recommended.

No appropriation was made for the fiscal year ending June 30, 1879.
Appropriation asked for next fiscal year $50,000 00

Fort on Ship Island, coast of Mississippi, in charge of Capt. A. N. Damrell, Corps of Engineers.—This work affords shelter to light-draught vessels moving in Mississippi Sound.

Operations during the year have been confined to necessary repairs of buildings.

The condition of this fort is the same as at the date of last annual report.

No appropriation was made for the fiscal year ending June 30, 1879.
No appropriation asked for next fiscal year.

Fort Pike, Rigolets Pass, Louisiana, in charge of Capt. C. W. Howell, Corps of Engineers.—This work commands the passage by vessels drawing 7 feet or less through the Rigolets into Lake Pontchartrain, and to the wharves on the lake front of New Orleans.

During the past fiscal year operations were confined to care and preservation of the work.

No appropriation was made for the fiscal year ending June 30, 1879.
No appropriation asked for next fiscal year.

Fort Macomb, Chef Menteur Pass, Louisiana, in charge of Capt. C. W. Howell, Corps of Engineers.—This work commands the passage by vessels drawing 4½ feet or less through the Bayou Chef Menteur into Lake Pontchartrain, and the road along Gentilly Ridge, to the city of New Orleans.

No work was done during the past fiscal year.

No appropriation was made for the fiscal year ending June 30, 1879.
No appropriation asked for next fiscal year.

Tower Dupré, Lake Borgne, Louisiana, in charge of Capt. C. W. Howell, Corps of Engineers.—This old work is situated at the entrance of Bayou Dupré into Lake Borgne.

No work was done during the past fiscal year.

No appropriation was made for the fiscal year ending June 30, 1879.
No appropriation asked for next fiscal year.

Battery Bienvenue, Lake Borgne, Louisiana, in charge of Capt. C. W. Howell, Corps of Engineers.—This battery is situated at the junction of two branches of the Bayou Bienvenue, about three miles from its mouth.

No work was done during the year.

No appropriation was made for the fiscal year ending June 30, 1879.
No appropriation asked for next fiscal year.

Tower at Proctorsville, Lake Borgne, Louisiana, in charge of Capt. C. W. Howell, Corps of Engineers.—No work was done during the past fiscal year.

No appropriation was made for the fiscal year ending June 30, 1879.
No appropriation asked for next fiscal year.

Fort Jackson, Mississippi River, Louisiana, in charge of Capt. C. W. Howell, Corps of Engineers.—This work and Fort Saint Philip, nearly opposite, are situated on the Mississippi River, about 65 miles below New Orleans, and are the most important of those guarding the approaches to New Orleans.

During the past fiscal year operations were confined to the care and preservation of the work.

For needful repairs to the work, and for continning preparations for mounting an armament of heavier caliber, an appropriation is asked.

No appropriation was made for the fiscal *year ending June 30, 1879.*
Appropriation asked *for next fiscal year* $25,000 00

Fort Saint Philip, Mississippi River, Louisiana, in charge of Capt. C. W. Howell, Corps of Engineers.—No work was done during the past fiscal year beyond that necessary for the care and preservation of the work.

For needful repairs to the main work and the exterior batteries of heavy guns an appropriation is recommended.

No appropriation was made for the fiscal year ending June 30, 1879.
Appropriation asked for next fiscal year..... $25,000 00

Fort Livingston, Barataria Bay, Louisiana, in charge of Capt. C. W. Howell, Corps of Engineers.—This barbette work is situated on the western end of Grand Terre Island, at the entrance to Barataria Bay. It guards the only approach to New Orleans by vessels drawing 7 feet or less, available on the west side of the Mississippi River. It also secures a safe anchorage and harbor of refuge for our light-draught coasters in time of war.

Operations during the past fiscal year were confined to a few slight repairs necessary for preservation of the buildings.

No appropriation was made for the fiscal year ending June 30, 1879.
No appropriation asked for next fiscal year.

Fort at Fort Point, entrance to San Francisco Harbor, California, in charge of Lieut. Col. C. S. Stewart, Corps of Engineers.—This important work, with its exterior barbette batteries for heavy guns, forms the defense of the south side of the Golden Gate, the entrance to San Francisco Harbor.

The work has been in charge of watchmen. Only such labor has been expended as was necessary for repairs.

To put the exterior batteries for heavy guns in condition to receive their armament and to make needful repairs, an appropriation is recommended.

No appropriation was made for the fiscal year ending June 30, 1879.
Appropriation asked for next fiscal year $100,000 00

Fort at Lime Point, San Francisco Harbor, California, in charge of Maj. George H. Mendell, Corps of Engineers.—This fort, and its detached earthen barbette works at Point Cavallo, Lime Point Ridge, and Gravelly Beach, constitute the defenses of the entrance to the harbor of San Francisco on the northern shore of the Golden Gate.

The works and public property have been under the charge of keepers throughout the year. No construction was in progress, all operations being suspended for want of funds. No changes have taken place either in number of platforms or in armament.

The batteries, including parapets, magazines, and platforms, remain in good condition and have been well cared for.

In order to complete the works as projected, and to include the rebuilding of the wharf and wooden reservoir-tank, and repairs of steamer, the sum of $100,000 will be required, $80,000 of which can be profitably expended in the year ending June 30, 1880.

No appropriation was made for the fiscal year ending June 30, 1879.
Appropriation asked for next fiscal year $80,000 00

Fort on Alcatraz Island, San Francisco Harbor, California, in charge of Maj. George H. Mendell, Corps of Engineers.—This work occupies a valuable position for the defense of the entrance to, and the inner waters of, the harbor of San Francisco, covering the whole of a rocky island, the shores of which rise abruptly from the water to a height sufficient to secure it from surprise. The fortifications have, from their inception, consisted chiefly of open barbette batteries for the heaviest guns.

A keeper was in charge of the works and public property throughout the year. No construction or other operations were carried on during the year except such repairs as were essential for the preservation of the works. These repairs were applied mainly to the wharf and in painting embrasure-irons, boat, and other articles which required it. The condition of the works remains good. No changes took place during the year either in the number of platforms or in the armament. The severe storms of the winter did a little damage to the wharf, and some to the slopes in several places.

The operations of the coming year will be confined to such repairs as the keeper can make.

For continuing the construction of the batteries in accordance with the existing project an appropriation is recommended.

No appropriation was made for the fiscal year ending June 30, 1879.
Appropriation asked for next fiscal year $50,000 00

Batteries at Point San José, San Francisco Harbor, California, in charge of Lieut. Col. C. S. Stewart, Corps of Engineers.—These temporary batteries are unserviceable. The timber platforms and the wood-work of the magazines are decayed and falling to pieces. No work has been done during the past fiscal year, and none is contemplated during the present year unless repairs necessary for practice firing.

Projects for new batteries for the occupation of this important point in the second line of defense for the bay and harbor of San Francisco have been prepared.

Batteries on Angel Island, San Francisco Harbor, California, in charge of Lieut. Col. C. S. Stewart, Corps of Engineers.—These three temporary earthworks, constructed during the late war, are essentially unserviceable. The platforms are decayed, and most of the carriages have been condemned. No expenditures have been made and none are at present contemplated.

Projects for open batteries for heavy guns and mortars to occupy points bearing upon the channels leading to the upper portion of the bay and the navy-yard at Mare Island have been made by the Board of Engineers for Fortifications.

Fort at San Diego, California, in charge of Lieut. Col. C. S. Stewart, Corps of Engineers.—This work is situated on Ballast Point, near the mouth of the bay and harbor of San Diego, and commands the channel of entrance thereto. It has been in charge of a watchman. The public buildings and property are in good condition.

To continue the construction of the barbette battery, no part of which is in condition to receive an armament, an appropriation is recommended.

No appropriation was made for the fiscal year ending June 30, 1879.
Appropriation asked for next fiscal year $70,000 00

Defenses at the mouth of the Columbia River, Oregon, in charge of Maj. John M. Wilson, Corps of Engineers.—The defenses consist of Fort Stevens, Point Adams, Oregon, on the south side, and Fort Canby, Cape Hancock, Washington Territory, on the north side of the entrance to the river. These works are earthen barbette batteries, and constitute the only defenses of the mouth of the Columbia River.

Fort Canby.—The three batteries require extensive repairs; two of the service magazines are entirely in ruins, and the third is not in good order; the wooden revetments and platforms are rapidly decaying; the roads leading to the batteries are in bad condition. No work, except that of painting the main magazine, has been done during the past year for want of funds.

Fort Stevens.—All the platforms, except that of the 15-inch gun, are badly decayed, and should be renewed; the drainage of the ditch requires attention, and the revetment of the sally-port is in bad condition. During the past year minor repairs have been made to the platforms and to the bridge across the moat at the sally-port.

A new revetment of brush and stone and several small wing-dams have been constructed along the shore of Point Adams to preserve the site of Fort Stevens, upon which the sea has been rapidly encroaching. This work has saved the fort from being undermined, but the forces brought to bear at this locality are so great that it impossible to tell what may occur during the next winter.

Surveys have been made of Point Adams, Clatsop Spit, and the Swash Channel, and charts prepared.

To put these works in good condition for defense, an appropriation is asked for next year.

No appropriation was made for the fiscal year ending June 30, 1879.
Appropriation asked for next fiscal year $30,000 00

BOARDS OF ENGINEERS.

The Board of Engineers for Fortifications, stationed in New York City, consisting of Col. J. G. Barnard, Col Z. B. Tower, and Lieut. Col. H. G. Wright, and, for the time being, the officer in charge of the defenses under consideration, has, during the past fiscal year, been chiefly engaged upon question of constructing permanent shot-beds in Fort Pickens at the present time; upon inquiry of the Secretary of the Interior as to what part of Dry Tortugas and other islands of the Florida Reef, reserved by order of the President on the 17th of September, 1841, are no longer required for military purposes; upon the necessity of retaining sites for defensive works, &c., and light-houses in Mobile Bay; Mississippi Sound; Amelia Island; Tampa Bay; Batton Island; Saint John's River; Charlotte Harbor; Sea Horse, North and Snake keys; Crooked Island, Saint Andrew's Bay; Flag, Dog, and Saint George's islands, Saint George's Sound; Saint Joseph's Bay; entrance to Santa Rosa Sound; and other reservations on the coasts of Louisiana, Mississippi, Alabama, and Florida: upon subject of preservation of site of Fort Hale, New Haven Harbor, Connecticut; upon present condition of the fort and recommendations concerning maintenance of present work until a permanent structure for the defense of that harbor is provided; upon present value of the site of Tower Dupré, Louisiana, as a military position for the defense of New Orleans and vicinity; upon inspection of Fort McHenry reservation and the subject of relinquishing to certain citizens of Baltimore, Md., a portion of that tract for the purposes of a dry-dock; upon invention of Mr. W. H. Hubbell of a "self acting-torpedo, or navy destroyer"; submitting detailed drawings showing modifications proposed by Board to convert the casemates of three of the fronts of Fort Schuyler, New York Harbor, to admit guns of the power of modern 80 or 100 ton rifles, behind shields of iron, with estimate of cost of same; submitting project for expenditure of appropriation for torpedo purposes for ensuing fiscal year; submitting detailed drawings exhibiting defenses designed for Galveston Harbor, Texas, with estimates of cost; submitting drawings exhibiting details of modifications proposed at Fort Carroll, Maryland, to adapt its casemates to receive guns of the power of the modern 80 or 100 ton rifle-gun, and providing for iron shields in front to enable them to resist an enemy's projectiles fired from guns of like character, and to arrange the barbette tier to receive the 15-inch smooth-bore or 12-

inch rifle gun, with estimates of cost of same; presenting plans of gun and mortar batteries on Cow Island and Great Hog Island, to control the entrance by way of Hussey's Sound into Casco Bay and Portland Harbor, Maine, with estimates of cost of same; upon Mr. John Rider's "gondola life-boat and raft," which he proposes to adapt to military purposes in moving troops across rivers, &c.; submitting plans showing proposed modification of the South Bluff Battery at Fort Washington, Potomac River, Maryland, and for construction, as far as determined upon at this time, of new batteries; in reply to inquiry of the Chief of Ordnance as to the dimensions of the embrasures of our permament works, with a view to the determination of casemate carriages therefor.

During the year the board has also continued the consideration of the subject of redoubts or keeps for the defense of the numerous isolated batteries already designed, when too distant from the main works to receive adequate support from the latter.

Plans for the modification of Fort Clinch, Fla., are completed, but withheld for revision and consideration of the subject of exterior batteries.

The study of the defense of San Francisco Harbor by means of torpedoes has been continued during the year.

The questions involved in the gradual deterioration of the Delaware breakwater harbor have received the attention of the board, its final action being deferred to enable further necessary surveys and current observations to be made by the local engineer.

The location of the 10-gun battery at Fort Washington is yet undetermined and will require a personal examination of the ground.

The question of the occupation of "The Dumplings," on Conanicut Island, opposite Fort Adams, R. I., and the plans for the modification of Fort Knox and its exterior batteries, are as yet undetermined.

The foregoing account of the recent labors of the board, considered in connection with the review embodied in its last annual report of its work for the ten years previous and of the present status of the system of coast and harbor defense, shows that a very important class of questions are yet demanding study.

The plans prepared for Forts Lafayette, Schuyler, and Carroll are but the initiation of like study in the category of important works requiring analogous modifications. Former reports of the board have shown that the exigencies of the case when, after the war, regular work on our coast defenses was resumed, required the Engineer Department to confine its operations mainly to the development of new earthen batteries and the improvement of the barbette batteries of existing masonry works, rather than to altering the works themselves.

What such alterations shall consist in must now be considered, and in case of the three works just mentioned, has been in a tentative way solved. Of the first-class works yet to be considered may be mentioned the fort at Sandy Hook; Fort Wadsworth, Staten Island ("Narrows" approach to New York); fort at Willets Point, opposite Fort Schuyler (East River approach to New York); Fort Delaware, Delaware Bay (approach to Philadelphia); Fort Wool, Hampton Roads (approach to Norfolk and James River); Fort Taylor, harbor of Key West, Fla.; Fort Jefferson, harbor of the Dry Tortugas; the fort at Fort Point, Golden Gate, California, entrance to San Francisco Bay.

For the proposed fort on Lime Point, the substitution of open earthen batteries at neighboring localities has been *resorted to.* The question

still remains open as to its construction and design, the plans originally made for it being no longer applicable.

Fort Morgan, entrance to Mobile Bay, and Forts Jackson and Saint Philip, on the Mississippi, below New Orleans, also require attention.

The same may be said in relation to a class of minor works, such as Fort Washington, Potomac River, Maryland; Fort Caswell, N. C., mouth of the Cape Fear River, and others.

TORPEDO DEFENSE.

The work of the board in this connection, for which special duty Maj. H. L. Abbot, in charge of the torpedo school at Willets Point, is a member, is exhibited as follows:

TORPEDO TRIALS.

The trials inaugurated in 1869 to develop the best system of torpedo defense for our harbors and navigable channels, have been steadily prosecuted as heretofore, the labor being supplied by the engineer troops at Willets Point. The following is a brief summary of the results attained during the past year:

Submerged ring.—Fifty shots have been fired to obtain data upon the following points:

1st. The possible detonation of gunpowder.

2d. The practical value of certain picrate compounds.

3d. The effect upon the intensity of the shock produced by motion communicated to the object receiving the blow.

4th. The completion of the data designed for a general mathematical discussion of the laws governing the transmission of the shock through the fluid. The conclusions reached are the following:

Within the limits of actual service no advantage can be derived from attempts to cause the detonation of gunpowder in torpedo-cases.

The picrate compounds are far inferior to dynamite as an explosive for use in submarine mining.

Lack of stability in the object receiving the shock enormously reduces the normal effect produced by the explosion; not exceeding 15 per cent. being utilized under certain conditions.

A final mathematical analysis of the mass of data bearing upon the laws governing the transmission of the shock through the fluid has been made by Major Abbot, and he has submitted formulæ based upon about 160 explosions, giving over 1,400 independent measurements upon dynamite acting upon rigidly-held gauges. Within the limits of measurements, which range from one-fourth of a pound to 200 pounds, and from 1 foot to 80 feet, the accordance between the formulæ and the data is surprising, considering the difficulty of the investigation.

Torpedo target.—The series of experiments with this target which was designed to represent a section from the bottom of a first-class ship-of-war of the present day, have been brought to a successful conclusion. Ten shots in all have been fired, the results furnishing, to a degree, the information for which it was constructed.

Torpedo cases.—A marked improvement has been made in the pattern adopted for the ground torpedo. The new form is a segment of a sphere, of which the height is two-thirds of the radius. It is made of cast iron 0.7 of an inch thick, with strong internal flanges. Experiment has shown that it will resist the explosion of a neighbor at a horizontal distance of 60 feet.

The adopted form of the buoyant torpedo is spherical, 32 inches in

diameter. In strong currents and deep water this lacks the needful buoyancy. As larger sizes are rarely required, and as the cost rapidly increases with the radius, trials have been made with a new type in which the desired buoyancy is given by uniting spherical ends by a cylindrical middle. Sizes corresponding in buoyancy to a 43-inch and a 46-inch spherical case have been adopted, after having resisted the explosion of a neighbor at a horizontal distance of 40 feet. Torpedoes of this pattern are now constructing for use at the Narrows of New York Harbor.

To test the endurance of torpedoes under exposure to salt water, waves, &c., one was planted in the channel off Willets Point in August, 1874. It is now entirely serviceable after a lapse of nearly four years. The wire mooring-rope is the only part which has needed renewal during this period.

Circuit closers.—Major Abbot has devised an inexpensive addition to the adopted pattern which has obviated its only fault, the necessity for the use of electricity of high potential for firing at will. The new improvement leaves nothing to be desired in this apparatus.

The telephone.—Experiments have been made to determine the value of this new invention for the torpedo service, and a form has been provisionally adopted which supplies a useful purpose in the system preferred for tracking the course of a hostile vessel attempting to pass the forts guarding a channel.

RECOMMENDATIONS.

The new laboratory at Willets Point has been completed and is now occupied. The proof-edition of the Torpedo Manual, prepared by Major Abbot, is finished and is in use in the instruction of the troops. These facts give increased weight to the recommendations of the board heretofore made, that the number of engineer soldiers kept under instruction in the practical duties of applying the torpedo system to the defense of our harbors should be increased to a minimum of 520 men. At present less than 150 instructed men are available for defending the whole of our extended coast.

The board also renews its recommendation of last year, that a special appropriation be asked for preparing our more important forts for operating submarine mines. An appropriation of $100,000 would do much to remove this serious defect in the existing works, which would be fatal to their efficiency in case of a sudden war with a maritime power.

The board also recommends that an appropriation of $100,000 be asked for continuing the purchase of torpedo materials, not easily to be obtained in haste, for instructing the engineer troops in the use of the same, and for continuing the series of trials now in progress.

The Board of Engineers for the Pacific Coast during the past fiscal year has consisted of Lieut. Col. B. S. Alexander, Lieut. Col. C. S. Stewart, Lieut. Col. R. S. Williamson, and Maj. George H. Mendell, with First Lieut. A. H. Payson recorder. Maj. John M. Wilson, Corps of Engineers, was associated with the board during a part of the time.

During the past fiscal year the board has acted and reported upon the survey, plans, and estimates for a canal around the Cascades of the Columbia River, and the improvements to the navigation of the Columbia River above the Cascades, Oregon; considered the encroachments of the sea and of the Columbia River on the shore of Point Adams, Oregon, endangering the site of Fort Stevens; and *studied the* question of surface and subsurface *currents in the Bay of San Francisco*, with a view of *establishing a system of torpedo or submarine* defense.

BATTALION OF ENGINEERS AND ENGINEER DEPOT.

Battalion of Engineers, commanded by Maj. H. L. Abbot, Corps of Engineers, headquarters Willets Point, eastern entrance to New York Harbor.

The strength of the Battalion of Engineers on June 30, 1878, was 13 commissioned officers and 195 enlisted men.

It was under the command of Maj. Henry L. Abbot, and was stationed as follows: At Willets Point, New York Harbor, the headquarters, Company A, Capt. T. H. Handbury; Company B, Capt. A. M. Miller; Company C, Capt. J. F. Gregory. At West Point, Company E, Capt. O. H. Ernst.

Detachments were stationed as follows, under command of the officers of engineers serving on the staff of commanding generals: Department of the Missouri, 1 sergeant and 1 private; Department of Dakota, 1 sergeant and 3 privates.

Until December 12, 1877, no recruiting was permitted beyond the re-enlistment of discharged soldiers in their former companies. After that date vacancies were filled as they occurred by enlistments at the posts where the companies were stationed. Upon this system 24 soldiers were enlisted during the year, 13 were re-enlisted, 4 deserted, and 2 deserters were apprehended.

At Willets Point, as heretofore, the troops have performed the ordinary military duties of the post; cared for, received, and issued the instruments and property pertaining to the engineer depot; remodeled a portion of the bridge equipage, and performed necessary labor upon the post and public buildings.

At West Point, Company E, in addition to ordinary post duties, has aided in the instruction of the cadets in pontoniering, signaling, telegraphy, and field fortification.

During the railroad riots which occurred in the summer of 1877, the headquarters and the three companies from Willets Point served at Baltimore, Md., Philadelphia, and Easton, Pa., performing their delicate duties in a manner to receive the marked commendation in orders of Major-General Hancock, commanding the division.

The following is the general system of instruction for the Engineer Battalion:

The company at West Point has received careful drilling in the various duties pertaining to its arm of service, except in submarine mining, for which there are no facilities.

Willets Point constitutes the regular school of application for the engineer service. The usual tour of service for the captains and battalion staff officers is four years. The subalterns for company duty consist of the most recent additions to the corps, who, upon graduating at the Military Academy at West Point, are attached to the companies at Willets Point for two or three years to become familiar with the routine of service with troops, and to learn the practical duties of their profession, such as the use of astronomical, meteorological, surveying, and reconnoitering instruments; photography, especially as used in the field for the duplication of campaign maps; the construction of military bridges; military mining; and field fortifications, and the use of torpedoes for harbor defense.

The enlisted men receive during the summer practical instruction, and during the winter theoretical instruction, in their duties as engineer soldiers.

The schools are conducted in each company by their commanding

officers. A system of marks similar to that at West Point is adopted, and the standing of each non-commissioned officer is published annually in battalion orders.

Much attention is devoted to the study and development of submarine mining for the defense of our coasts against hostile fleets, a duty which has been added to the engineer service since the civil war.

A fine laboratory has been constructed, and officers and men are thoroughly trained in the application of electricity to ignitions, the manipulation of defensive torpedoes, and the use of modern explosive compounds. The immense importance of this new branch of national defense is not properly appreciated, and the number of enlisted men now under instruction is entirely inadequate to the needs of the service. In this connection I desire to respectfully urge upon the Secretary of War the following recommendation contained in my last annual report, remarking that the engineer troops, while ordinarily employed in their separate and special duties, have proved themselves to be available in emergencies for excellent service as infantry of the line. Indeed, in discipline, marksmanship, and drill they are second to none in the service.

In our service, as in that of Great Britain and other nations, the duty of devising and perfecting a system of torpedo defense to be used in combination with the forts, and of practically applying it in case of war, has been assigned to the engineer troops. The legal organization of the battalion (752 enlisted men) is sufficient to warrant a reasonable expectation that, with the needful material in store, this highly important duty will be satisfactorily performed. Under existing orders, issued at the recent reduction of the Army, the force authorized to be kept in service is fixed at 200 men, a number quite insufficient to afford any proper grounds for believing that even our more important sea-ports could be properly protected by torpedoes in time to prevent their destruction. Every effort is now making to thoroughly prepare the men for these duties, which involve long training and higher intelligence than it is common to find in the ranks. Individual records are kept, showing the qualifications of each man, as determined by his instructors from his regular drills and exercises. But still the fact remains that the force is too small to perform the responsible duties assigned to it, and I therefore feel it my duty to urge that the organization may be recruited to 520 men, the number judged to be the minimum consistent with a reasonable state of preparation for unexpected hostilities. This number is but little more than two-thirds of the maximum fixed by law, and no increase in the legal organization is therefore needed.

Engineer post and depot at Willets Point, New York Harbor, commanded by Maj. H. L. Abbot, Corps of Engineers.—At Willets Point is situated the engineer depot of the Army, where the bridge equipage and tools for field-service, the torpedo material collected for the defense of our principal harbors, and the astronomical and surveying instruments used by the Corps of Engineers upon the various military and civil works of the country, are collected, stored, and issued as required. The duty of guarding and handling this property is performed exclusively by soldiers of engineers.

The post has developed into a useful school of application for the engineer service, where officers and men are exercised in their various military duties, comprising submarine mining for the defense of our harbors, military mining in land operations, military bridge making, field fortifications, military reconnaissance and map making with armies in the field, military photography and map printing, &c. The officers are also furnished with the needful facilities for becoming familiar with the instruments and methods in use upon the various civil works of the corps, such as practical astronomy, surveys, explorations, hydraulic operations usual in river and harbor improvements, &c. It has become customary, before assigning them as assistants upon the various works conducted by the corps, to require engineer officers, on graduating from the Military Academy at West Point, to spend about two years at Willets Point, per-

forming ordinary company duty with the troops, and devoting their leisure time to acquiring practical experience in the duties named above.

The only appropriations requested for the coming year, are the usual amounts of $1,000 for the purchase of engineer materials to be used for the instruction of the troops, and $4,000 for the contingent expenses named below.

Estimate of funds required for the Battalion of Engineers and Engineer Depot at Willets Point, New York Harbor, for the fiscal year ending June 30, 1880.

For the purchase of engineer materials to continue the present course of instruction of the battalion in field-engineering	$1,000 00
For the incidental expenses of the depot, such as remodeling ponton-trains, repairing instruments, purchasing fuel, forage, stationery, chemicals, extra-duty pay for soldiers engaged in special skilled labor, such as wheelwright work, printing, binding, photographing, and lithographing engineer documents, &c.	4,000 00
Total	5,000 00

CURRENT OBSERVATIONS IN REFERENCE TO TORPEDO DEFENSE.

Some questions having arisen regarding the practicability of applying torpedoes in the defense of the bay and harbor of San Francisco, Cal., on account of the supposed velocities of the surface and subsurface currents, a series of observations were made in this connection during the past year. The report of Lieut. A. H. Payson, Corps of Engineers, who conducted the observations, is of interest, and will be found in Appendix H3 of this report.

RIVER AND HARBOR IMPROVEMENTS.

On the 1st day of July, 1877, there was available for the continuation of work upon the improvement of rivers and harbors the sum of $4,274,662.20, being the balance of the appropriation of August 14, 1876, and of previous dates.

During the fiscal year ending June 30, 1878, Congress made the following appropriations, and as the amounts were made at once available, the whole sum applicable to carrying on works of improvement during the fiscal year was $4,403,162.20, viz:

For the removal of snags and other obstructions from the Mississippi, Missouri, and Arkansas Rivers, &c., $40,000.

For the purpose of opening the navigation of Red River, above Shreveport, in the State of Louisiana, and keeping said navigation open and free from rafts, &c., $6,000.

To pay the current expenses of operating the Des Moines Rapids Canal, on the Upper Mississippi River, until July 1, 1878, $7,500.

For the purpose of continuing the improvements of Galveston Harbor, in the State of Texas, $75,000.

Of the above available sum, $4,403,162.20, there has been expended during the fiscal year $2,794,483.72, leaving balance applicable to the continuation of work July 1, 1878, of $1,608,678.48.

The "Act making appropriations for the construction, repair, preservation and completion of certain public works on rivers and harbors and for other purposes," approved June 18, 1878, made provision for 215 works and for surveys or examinations at 116 localities. The total amount appropriated is $8,201,700, and it is distributed among the several works in sums varying from $1,000 to $350,000.

As soon as practicable after it was known that the amounts therein appropriated were made subject to requisition, the officers in charge of the various districts were called upon for projects for the application of the amounts made available to the works of improvement. On the approval of the projects submitted, steps have been taken for putting the work at once into execution, and they are now being conducted under the contract system, and by means of hired labor and purchase of material in open market, as appeared to be most advantageous to the government.

The examinations or surveys "and estimates of cost of improvements proper to be made" at the several points and localities named in the second section of the act, are now in hand, and it is expected that reports will be received in time to be submitted during the approaching session of Congress.

A brief summary is given below, setting forth for each improvement its condition and the amount of work done during the fiscal year, and accompanied by a money statement giving the amount expended during the year, the probable amount required for the completion of the adopted project, and an estimate of the amount that can profitably be expended during the fiscal year ending June 30, 1880. These estimates were submitted in tabular form by letter of September 18, 1878, and will, it is expected, be printed in the Book of Estimates, prepared and submitted to Congress by the honorable the Secretary of the Treasury. For full and detailed information respecting any particular improvement or survey, attention is respectfully invited to the report of the officer in charge, which will be found in the appendix.

The report of the commission appointed by authority of the joint resolution of March 3, 1877, "to examine into the matter of contracts made by and between the United States and the Moline Water-Power Company, as to the water-power at Moline, Illinois," was submitted to Congress during its first session by the Secretary of War, and may be found printed in Ex. Doc. No. 21, House of Representatives, Forty-fifth Congress, first session. A copy of the report is herewith, forming Appendix R.

The Board of Engineer Officers constituted in July of the present year by your direction, to take into consideration the improvement of the low-water navigation of the Mississippi and Missouri rivers, and to submit a plan therefor, together with recommendations for the most practicable measures to be adopted from time to time, in order to secure its earliest and most economical completion, has entered upon the duties assigned to it.

The board is instructed to consider how far the information already at hand, from surveys and investigations heretofore made, can be made available to devise a general system of works for the permanent improvement of the low-water navigation of those rivers; what additional data will be required; in what manner and by what system of survey it may be best obtained, and what localities should be first surveyed, having in view the most pressing needs of navigation; and should it deem the information already at hand sufficient to enable it to prepare a systematic plan of improvement, in whole or in part, it is instructed to do so, and, if practicable, in time to admit of the subject being submitted to Congress at its next session.

Certain surveys have been indicated by the board as essential to the consideration of its duties as above prescribed, and they have been ordered and are in progress.

ATLANTIC COAST.

IMPROVEMENT OF RIVERS AND HARBORS IN THE STATES OF MAINE, NEW HAMPSHIRE, AND MASSACHUSETTS.

Officer in charge, Lieut. Col. George Thom, Corps of Engineers.

1. *Improvement of Saint Croix River, above the "Ledge," Maine.*—This river throughout its whole extent forms a part of the international boundary between Maine and New Brunswick. A survey of it was made in 1873, under the direction of Lieut. Col. Thom, from the "Ledge" up to the toll-bridge between Calais and Saint Stephens, the head of navigation, a distance of about 5 miles, with a view to the improvement of this portion of the river. The channel of the river was found to be much obstructed by shoals, caused by the deposit of slabs, edgings, and sawdust thrown into the river from the saw-mills above, then estimated at not less than 1,000,000 cubic yards. To open a channel of practicable width and depth through these shoals (say 200 feet in width and 9 feet in depth at mean low-water, and 29 feet at mean high-water) it is estimated would require the excavation of 235,000 cubic yards of "mill-waste," at a probable cost of $150,000.

The following appropriations have been made by Congress for the improvement of this river, to wit:

By act approved March 2, 1867	$15,000 00
By act approved March 3, 1873	10,000 00
By act approved June 23, 1874	10,000 00
Total	35,000 00

The act of March 2, 1867, contained the proviso that—

> The province of New Brunswick contribute and pay to the proper disbursing officer a like sum for said purpose, said payment being made on condition that in no event shall the province of New Brunswick be called upon for more than half the sum actually expended for said purpose.

In 1873, the Dominion of Canada appropriated the sum of $25,000 for the improvement of this river; but in consideration of the fact that the obstructions to its navigation have been caused by the deposit of the "waste" from the saw-mills above, and that no law is in force for preventing the continuance of this practice, the department of public works of the Dominion of Canada declined to authorize the expenditure of the appropriation until satisfied that this practice is permanently discontinued.

July 1, 1877, amount available	$34,000 00
July 1, 1878, amount available	34,000 00

(See Appendix A 1.)

2. *Improvement of Penobscot River, Maine.*—The work originally projected for the improvement of this river consisted—

In the enlargement and straightening of its channel through the several bars and shoals at and near Bangor, so as to have a width of not less than 200 feet, and a depth not less than 11 feet at low tide (or 24 feet at high tide) in the lowest stages of the river, giving about 14 feet at low tide in its ordinary stages.

In breaking up and removing all the sunken ledges and bowlders in the harbor of Bangor outside the main channel, down to the level of the general bed of the river, including Independence Rock, Gulliver's Rock, the ledge near Steamboat Wharf, and those near Dole's Wharf, Green's

Pier and Green's Pier Ledge, and a ledge outside of it; also the bowlders and ledges in front of the wharves at High Head.

At the beginning of the fiscal year (July 1, 1877) the improvement of all the bars and shoals then projected had been completed, with the exception of the channel through the Middle Ground at Bangor; and all the sunken rocks had been broken up and removed to the extent projected, with the exception of several outcroppings of ledge discovered in 1875–'76 in and near the Middle Ground Channel, for the partial removal of which a contract had been made; a contract had also been made for completing all the dredging on the Middle Ground, under which considerable progress had then been made.

During the past year the removal of the ledge in the Middle Ground Channel has been carried on under contract, and has been about half completed by the breaking up and removal of about 70 cubic yards of the ledge, the remainder of which will probably be completed before the close of the present season, leaving 80 cubic yards of ledge outside the channel to be removed under the appropriation of June 18, 1878. The excavation of the Middle Ground Channel by *dredging* was completed in September, 1877.

The river and harbor act of March 3, 1875, appropriating $25,000 for Penobscot River, provided that $10,000 of it should be expended for the improvement of the river at and near Bucksport Narrows (18 miles below Bangor), which amount was applied to the partial removal, by dredging, of the Middle Ground in front of the wharves at Bucksport to a depth of 12 feet at mean low water or 22.3 feet at ordinary high water.

The river and harbor act of August 14, 1876, appropriating $10,000 for Penobscot River, provided that $4,000 of it should also be expended at and near Bucksport Narrows. This amount was expended in September, October, and November last in continuing the work at the Middle Ground.

For deepening the channel in front of High Head wharves, at Bangor, by dredging, and the removal of sunken rocks, as projected, the additional sum of $6,000 will be required.

The officer in charge of this work states that the throwing of sawdust into this river is still continued to a very great extent, and to the serious detriment of its navigation. In view of this, and of the fact that several other navigable rivers in his district, now being improved by the United States Government, are also being injured by the throwing in of slabs, edgings, and sawdust, by building of piers and bridge-draws in improper places, and otherwise, he suggests the passage of some general law for the protection and preservation of all navigable waters under the control of the United States Government, for the improvement of which Congress has already made or may hereafter make appropriations: This suggestion is concurred in by this office.

July 1, 1877, amount available	$22,284 30	
Amount appropriated by act approved June 18, 1878	12,000 00	
		$34,284 30
July 1, 1878, amount expended during fiscal year	18,786 57	
July 1, 1878, outstanding liabilities	477 00	
		19,263 57
July 1, 1878, amount available		15,020 73
Amount (estimated) required for completion of existing project		6,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880		6,000 00

(See Appendix A 2.)

3. *Improvement of Belfast Harbor, Maine.*—A survey of this harbor was

made in July and August, 1875, in compliance with the river and harbor act of March 3, 1875, by which it was ascertained that to so improve it as to afford a safe anchorage for shipping in all storms and have a suitable depth for the several steamers and other vessels that touch and lie there, in all stages of the tide, would require a breakwater, at a cost as estimated by the engineer in charge of same, of $310,000, and dredging and rock excavation at an estimated cost of $35,000.

By the river and harbor act of August 14, 1876, the sum of $5,000 was appropriated for the improvement of this harbor, which was applied to the partial removal of the rocky shoal abreast of Lane's wharf, for which a contract was made. This work was completed in November last. For continuing the removal of this shoal and the shoals below to the projected depth an additional appropriation of $12,000 has been made by act of June 18, 1878.

July 1, 1877, amount available	$4,991 00	
Amount appropriated by act approved June 18, 1878	12,000 00	
		$16,991 00
July 1, 1878, amount expended during fiscal year	4,959 04	
July 1, 1878, amount available		$12,031 96
Amount (estimated) required for completion of existing project	18,000 00	
Amount that can be profitably expended in fiscal year ending June 30, 1880	18,000 00	

(See Appendix A 3.)

4. *Improvement of Kennebec River, Maine.*—Under a contract made May 6, 1875, for the removal of Dry Rock to a depth of 12 feet at mean low-water, operations have been carried on during the past fiscal year, resulting in the removal of 545 cubic yards of the rock, making a total of 1,775 cubic yards removed under that contract. This work was completed in September last, so that all the work projected for the improvement of this river has been completed, whereby the channel up to Gardiner has been made safe and navigable for a width of not less than 100 feet and for a depth of 10 feet at low tide (or 15½ feet at high tide) in its lowest summer stages; and from Gardiner to Augusta, a distance of 7 miles more, it has also been improved for a width of not less than 100 feet, so as to have not less than 6½ feet at low tide (or 11½ feet at high tide) in the lowest summer stages of the river.

July 1, 1877, amount available	$9,489 56
July 1, 1878, amount expended during fiscal year	9,489 56

(See Appendix A 4.)

5. *Improvement at the gut opposite Bath, Me.*—The following work has been done for the improvement of this locality under the appropriations made by the river and harbor acts of July 11, 1870, and March 3, 1871, aggregating $16,500, viz:

1. The removal of Boiler Rock to a depth of 10 feet at mean low water or 16½ feet at mean high water.
2. The removal to a depth of 9 feet at mean low water of the ledge extending from Boiler Rock northward toward the shore.
3. The removal of two wrecks of vessels lying in mid-channel above and near Upper Hell Gate.
4. Dredging a channel through the bar next above Upper Hell Gate to a width of 100 feet and a depth of 10 feet at mean low water or 16½ feet at mean high water.
5. The breaking up and removal of points of ledge which projected into the river from its southern shore at the Upper Hell Gate (amount-

ing altogether to about 1,000 cubic yards), whereby the water-way was increased from a width of about 100 to about 150 feet.

This work was completed in 1872.

Under the appropriation of $17,000 made by the river and harbor act of June 18, 1878, the following work has been projected, viz:

1. Straightening, widening, and deepening the channel through the shoal above Upper Hell Gate.

2. Widening the passage through Upper Hell Gate.

3. Removing the sunken ledges from the river below Upper Hell Gate, so as to make a safe and direct channel to the north of Marsh Island.

The amount now available for this work is believed to be sufficient for its completion.

Amount appropriated by act approved June 18, 1878	$17,000 00
July 1, 1878, amount available	17,000 00

(See Appendix A 5.)

6. *Improvement of Portland Harbor, Maine.*—All the work projected for the improvement of this harbor has been completed, with the exception of the dredging in front of the harbor commissioner's line above Merrill's wharf; but this work will be done only on condition that the several wharves above Merrill's wharf will be removed, so far as they extend beyond the harbor line. The funds now available are sufficient for this purpose.

July 1, 1877, amount available	$42,930 10
July 1, 1878, amount expended during fiscal year	1,021 72
July 1, 1878, amount available	41,908 38

(See Appendix A 6.)

7. *Improvement at Richmond's Island, Maine.*—The improvement projected for this place consists in making a harbor of refuge by means of a rubble-stone breakwater, to connect the island with mainland. The length of the proposed breakwater is about 2,000 feet, with an average thickness of 25 to 30 feet, and a height of 4 feet above ordinary high-water. During the past fiscal year work has been suspended for want of funds.

Under the appropriation of $6,000 made by act approved June 18, 1878, it is probable that 4,000 tons more of stone will be furnished and placed upon the work. To complete it in accordance with the original estimate 6,000 tons more will be needed, for which an appropriation of $9,000 will be required.

Amount appropriated by act approved June 18, 1878	$6,000 00
July 1, 1878, amount available	6,000 00
Amount (estimated) required for completion of existing project	9,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.	9,000 00

(See Appendix A 7.)

8. *Improvement of Kennebunk River, Maine.*—The work projected for the improvement of this river under the appropriation of $10,000 made by the river and harbor acts of July, 1870, and March, 1871, consisted in the extension and repair of the two stone piers at its mouth, and the repair of the United States Government wharf, a short distance above. This work was completed in 1872. Under the appropriation of $5,000 made by the river and harbor act of August 14, 1876, the channel of the river has been straightened, widened, and deepened, by dredging at the Wading Place and Mitchell's Point, so as to have a depth of 4 feet at mean low-water, or about 13 feet at *mean high-water.* This work was commenced in *July and completed in September* last, with 6,450 cubic

yards of dredging. Extensive repairs have also been made where most necessary on the stone piers at the mouth of the river, as well as on the government wharf above. In order to *complete* all the work now projected for the improvement of this river, there will be required, as estimated and recommended by the engineer officer in charge, a further appropriation of $6,000.

July 1, 1877, amount available	$4,992 00
July 1, 1878, amount expended during fiscal year	4,992 00
Amount (estimated) required for completion of existing project	6,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.	6,000 00

(See Appendix A 8.)

9. *Improvement of Cocheco River, New Hampshire.*—The original project for the improvement of this river, based on an examination made in 1870, consisted of making a channel not less than 40 feet in width and 4 feet in depth at mean low-water, from the foot of the Lower Narrows up to Collins wharf (at the head of the Upper Narrows), the estimated cost of which was $45,000, as shown in the annual report of 1871. More accurate and extended surveys, since made, have shown the practicability and importance of extending this improvement up to the packet landing, the total estimate for which, as now amended, is $85,000.

Under the several appropriations made from 1871 to 1876, inclusive, for this river the following work has been done, viz:

1. A channel has been opened through the ledge at the Upper Narrows for a length of 430 feet, and to a width of 40 feet and a depth of 4 feet at mean low-water, or about 11 feet at ordinary high-water.

2. A channel has been opened through the ledge next above the Upper Narrows for a length of 260 feet, and to a width of 40 feet and a depth of 4 feet at mean low-water.

3. The channel at and near the Lower Narrows has been nearly completed by the removal of sunken ledges and bowlders; and numerous scattered bowlders which were dangerous obstructions to navigation at Trickey's Shoal, Clement's Point Shoal, and elsewhere, have been broken up and removed.

4. The channel and basin have been opened by dredging through the several shoals that existed between the Lower Narrows and Packet Landing, except at Gulf Shoal.

This completes all the work to be done for the improvement of this river, except the opening of a channel through Gulf Shoal next below the Upper Narrows.

Under the appropriation of $14,000 made by act of August 14, 1876, the following work was done during the past fiscal year, to wit:

Twelve thousand three hundred and seventy-one cubic yards of dredging finished by contract in November last, in completion of the basin at Packet Landing and of the channel between that point and the Lower Narrows, with the exception of the excavation of a channel through Gulf Shoal, next below the Upper Narrows. Sunken ledges and bowlders have also been broken up and removed at and near Clement's Point Shoal, Trickey's Shoal, the Upper and Lower Narrows, and at Dover Point, altogether about 300 cubic yards, which was completed in August, 1877.

Under the appropriation of $6,000 made by the river and harbor act of June 18, 1878, it is proposed to remove the obstructions at Gulf Shoal, which will complete all the work that has been projected for the improvement of this river; and it is believed that the funds now available will be sufficient for that purpose.

July 1, 1877, amount available	$11,228 08	
Amount appropriated by act approved June 18, 1878	6,000 00	
		$17,228 08
July 1, 1878, amount expended during fiscal year		10,332 25
July 1, 1878, amount available		6,895 83

(See Appendix A 9.)

10. *Improvement of Merrimac River, including the harbor of Newburyport, Massachusetts.*—All work projected for improving the falls of this river above Haverhill, Mass., has been completed to the extent now deemed necessary. Newburyport Harbor, at the mouth of the river, has also been improved by the removal of South Gangeway Rock and of a wrecked schooner, and some progress has been made in the removal of North Gangeway Rock.

Between Newburyport and Haverhill the river has been improved by deepening the shoals and the removal of numerous bowlders which obstructed the channel above and below Rock's Bridge, including Petty Rock below and Little Currier Rock above the bridge.

The work done during the past fiscal year has consisted of the removal of numerous sunken bowlders from the channel near Silby's Island.

The sum of $10,000, which was appropriated for this river by act of June 18, 1878, is to be applied to the removal of sunken ledges at the mouth of the river in Newburyport Harbor.

For completing all the work now projected for the improvement of Newburyport Harbor, the additional sum of $15,000 will be required.

July 1, 1877, amount available	$1,251 10	
Amount appropriated by act approved June 18, 1878	10,000 00	
		$11,251 10
July 1, 1878, amount expended during fiscal year		1,071 00
July 1, 1878, amount available		10,180 10
Amount (estimated) required for completion of existing project		15,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880		15,000 00

(See Appendix A 10.)

11. *Improvement of Boston Harbor, Massachusetts.*—The following is a statement of the present condition of the several works completed, projected, and in progress for the improvement of this harbor, and the progress made upon them during the past fiscal year, viz:

Sea-wall on Point Allerton.—This wall was completed in May, 1874, together with a riprap apron-work for the protection of its foundation. Its total length is 1,202 feet. It is now in excellent condition in every respect, and fully answers the purpose intended.

Sea-wall on Great Brewster Island.—This wall is 2,800 feet in length, and was built for the protection of the north and south heads of that island, and was completed in 1870. It is in good condition and requires but few repairs.

Sea-walls on Lovell's Island.—The two sea-walls on this island were built by the United States Government, one in 1843 for the protection of its north head, 803 feet in length, and the other in 1868–'69 for the protection of southeast bluff, for a length of about 800 feet. For the protection of the shore line next south of the north-head wall, and next south of the southeastern wall, apron-work and jetties of rubble-stone were added in 1873. The wall on the southeast bluff has been much damaged by recent storms, and its height is to be increased 4 feet by adding two more courses, and is to be otherwise repaired, at a probable total cost of $15,000. Contracts have been made for all the stone required

for this work, and preparations have been nearly completed for building the wall. The other wall and apron-work are now in good condition, requiring no repairs, and fully answer the purposes intended.

Sea-wall on Gallop's Island.—This wall was commenced in 1868 and completed in September, 1871. It is 1,785½ feet in length, and has its foundation protected for nearly its whole extent by a riprap apron-work and stone jetties, which were added in 1873–'74. This work is in good condition, and fully answers, in every respect, the purpose for which it was intended.

Sea-wall on the north head of Long Island.—This wall was commenced in 1870 and completed in the latter part of July, 1874, for a total length of 2,081¾ feet. For the protection of its concrete foundation, a riprap apron and jetties were built in 1874 on those parts where most exposed to injury by storms and currents, having been completed early in August, 1874. This work is in good condition, requiring no repairs, and fully answers the purpose intended.

Sea-walls on Deer Island.—The three sea-walls on this island were built about thirty-five years ago for the protection and preservation of the north, middle, and south heads, and were, respectively, 1,740, 840, and 420 feet in length. The injury which these walls had sustained from the violence of the storms was such as to necessitate the rebuilding of them to a great extent. This was commenced in 1864 and completed in 1869.

Straightening, widening, and deepening the main ship-channel at the west end of Great Brewster spit.—This work consisted in the removal, by dredging, of the southern portion of this spit, so as to give to the channel a width of 600 feet for a depth of 23 feet at mean low-water. Under a contract made in September, 1874, the dredging, which was commenced in October, 1874, was completed in August, 1875. During these operations a ledge was laid bare, of which 95½ cubic yards have since been broken up and removed to the required depth of 23 feet at mean low-water.

Straightening, widening, and deepening the main ship-channel at the southeast and southwest points of Lovell's Island.—This improvement consists in widening the channel so as to have a width of 600 feet for a depth of 23 feet at mean low-water.

Under the appropriation of June 23, 1874, a contract was made in September, 1874, for the dredging at the southeast point of this island. Work under this contract was commenced in October, 1874, and was completed in September, 1875.

For completing the improvement at and near the southwest point of this island, which was suspended in 1869, a contract was made in June, 1877, and was completed in September following.

Straightening, widening, and deepening the main ship-channel at the upper middle bar.—The improvement projected for this bar consists in excavating a channel for about 4,400 feet in length to a width of 600 feet and for a depth of 23 feet at mean low-water, the mean rise and fall of the tide being 10 feet. Dredging operations were commenced on the bar in 1870, and were continued, with intervals of suspension for want of funds, up to the 16th of November, 1876, when they were finally completed by a total of 268,278 cubic yards of dredging. In these dredging operations a sunken ledge was uncovered, containing about 80 cubic yards above grade.

Under a contract made for its removal 50 cubic yards have been broken up and removed during the past year; the remainder of it will probably be removed by the end of July, 1878.

Removal of Nash's Rock (Shoal).—This shoal lies in the entrance to *Boston Harbor, about* one-third of the way over from Brewster's Spit to

Point Allerton. By a survey made in 1873, under the direction of the engineer officer now in charge, it was ascertained that this shoal (previously known as Nash's Rock) is covered with bowlders, shingle, gravel, &c., and has an area of about 640 superficial yards with less than 21 feet of water over it at mean low-water, and an area of about 9 acres with less than 23 feet of water over it. The improvement here projected consists in its removal to a depth of 21 feet at mean low-water, which, under a contract made May 19, 1875, was about half completed in September, 1876.

About 320 tons of ledge and bowlders have been removed from this shoal during the past year, leaving about 40 tons yet to be removed.

Removal of Kelly's Rock.—This rock lies in the main ship-channel, distant about 700 yards, in a direction southeast by south from Bug light (at "the Narrows"), and in the line of entrance buoy No. 1 and Bug light, and has always been a very dangerous obstruction to navigation.

In 1869 work was commenced upon the removal of this ledge to the depth of 23 feet at mean low-water, and was continued up to the end of 1870, leaving, as shown by surveys since made, a large area not having the required depth.

Under the appropriation of March 3, 1875, a contract was made May 14, 1875, for completing the removal of this rock. Work was commenced under this contract in the latter part of May, and was satisfactorily completed in September, 1875. During these operations of 1875, '76, and '77 new ledges were discovered in the vicinity of Kelly's Rock, above and below it, having on the shoalest part a depth of 17½ feet at mean low-water. To reduce them to the projected depth of 23 feet at mean low-water required 350 cubic yards of excavation.

Under a contract made in June, 1877, for the removal of 200 cubic yards of this ledge at $50 per cubic yard, 76½ cubic yards have been broken up and removed to grade during the past year. Under the appropriation made by the river and harbor act of June 18, 1878, proposals will be invited to complete the removal of all these ledges by contract.

Removal of Tower Rock.—This rock was situated in the main ship-channel at "the Narrows," about 100 yards to the southwest of Great Brewster Spit light. It was blasted out and removed in 1867 to the projected depth of 23 feet at mean low-water.

Removal of Corwin Rock.—This rock was situated in the main ship-channel at "the Narrows," about 200 yards to the southwest of Great Brewster Spit light. It was blasted out and removed in the years 1868 and 1869 to the projected depth of 23 feet at mean low-water.

Removal of sunken ledge between George's Island and Great Brewster Spit.—This ledge was discovered in September, 1872, in a resurvey of "the Narrows," made under the direction of the engineer officer now in charge. It was situated near the middle of the main ship-channel, distant about 317 yards, in a direction west by south from Bug light. It had but 18.9 feet of water over it at mean low-water, and was consequently a dangerous obstruction to navigation for the European steamers and other large vessels.

Under a contract made August 31, 1874, the removal of this ledge was completed in September, 1874, to the projected depth of 23 feet at mean low-water.

Removal of Barrel Rock in Broad Sound.—This was a bowlder, lying about one mile north of west from Green Island and near the sailing line of the Portland and other Maine steamers. It had only 4 feet of water over it at low tide, *and in thick weather was a* dangerous obstacle to navigation. *It was removed in 1869.*

Removal of State and Palmyra Rocks.—By a survey made in 1873, under the direction of the engineer officer now in charge, it was ascertained that these dangerous rocks, the position and character of which had previously been but little known, consisted of bowlders and ledges, lying on the southern spurs of the "Lower Middle," which ocean-steamers and other large vessels had occasionally struck.

Under a contract made August 31, 1874, for the removal of these sunken rocks, work was commenced upon them in September, 1874, and on the 15th of June, 1875, their removal was completed.

Removal of wreck of schooner Delos.—This vessel was sunk in 1872 in Nantasket Roads, about 100 yards from Fort Warren wharf, in about 22 feet of water at mean low-water, and was broken up and removed in May and June, 1873.

Improvement of Hingham Harbor, Massachusetts.—In the appropriation for Boston Harbor, made by act of March 3, 1875, provision was made for the improvement of Hingham Harbor, Massachusetts, to an extent not exceeding in cost $10,000.

The project for its improvement consisted in widening and deepening the main channel so as to have a width of not less than 100 feet and a depth of 8 feet at mean low-water (or about 6 feet at low-water in spring tides) up to the wharves of Hingham, requiring 25,160 cubic yards of dredging and 80 cubic yards of ledge excavation. This work has been completed.

From the report of the engineer officer in charge, it is seen that nearly all the works hitherto projected for the improvement of Boston Harbor have been completed, and the following remain to be completed, viz:

1. The removal of about 275 cubic yards of sunken ledges, discovered in 1875, '76, and '77, in the vicinity of Kelly's Rock, and about 30 cubic yards of ledge at the Upper Middle.

2. Completing the removal of Nash's Rock (Shoal), arrangements having been made for doing it the present season.

3. The removal of Man-of-War Shoal, in the upper harbor, requiring about 65,000 cubic yards of dredging, for which funds are available under the appropriation made therefor by the river and harbor act of June 18, 1878.

4. Raising and repairing the southeastern sea-wall on Lovell's Island, for which funds are now available under the river and harbor act of June 18, 1878.

5. Widening and deepening the channel through Anchorage Shoal as now projected, which, it is estimated, will require 135,000 cubic yards of dredging.

6. Widening the channel at the Lower Middle as now projected, which, it is estimated, will require 5,000 cubic yards of dredging.

7. One hundred and twenty-five thousand cubic yards of dredging for improving the upper harbor, near the mouth of Mystic River.

For the work described in the last three items (5, 6, and 7) no appropriations have as yet been made by Congress, but for which the sum of $165,000 will be required.

July 1, 1877, amount available	$41, 291 61	
Amount appropriated by act approved June 18, 1878	55, 000 00	
		$96, 291 61
July 1, 1878, amount expended during fiscal year	21, 090 17	
July 1, 1878, outstanding liabilities	4, 500 20	
		25, 590 37
July 1, 1878, amount available		70, 701 24
Amount (estimated) required for completion of existing project		165, 000 00

(See Appendix A 11.)

12. *Improvement of Plymouth Harbor, Massachusetts.*—The several appropriations heretofore made for this harbor have been applied to the construction of bulkheads, jetties, and groins for the preservation and strengthening of Long Beach, upon which the harbor depends for its existence; also to the partial opening of a channel leading from the Middle Ground up to the wharves of Plymouth. This channel is projected to have a width of 100 to 125 feet for a depth of 6 to 8 feet at mean low-water, or 16 to 18 feet at mean high-water. In 1870 it was opened to a width of about 50 feet up to Long wharf, and to a depth of 6 feet at mean low-water. For completing this channel as now estimated by the engineer officer in charge, and for the annual repairs of the works built for the preservation and protection of Long Beach, an additional appropriation of $25,000 will be required.

July 1, 1877, amount available	$93 92	
Amount appropriated by act approved June 18, 1878	5, 000 00	
		$5, 093 92
July 1, 1878, amount expended during fiscal year		5 85
July 1, 1878, amount available		5, 088 07
Amount (estimated) required for completion of existing project		25, 000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880		25, 000 00

(See Appendix A. 12.)

13. *Improvement of Provincetown Harbor, Massachusetts.*—The several appropriations heretofore made for the preservation and improvement of this harbor have been applied to the construction of the following works, viz:

Bulkheads and jetties of various descriptions have been built from time to time along Beach Point, for its preservation and protection, both by the United States Government and by the local authorities.

A dike was built in 1868 and 1869 by the State of Massachusetts across the outlet of East Harbor Creek.

A dike was built in 1868 and 1869 by the United States Government across East Harbor Creek, at the Wading Place, near High Head, about 2 miles above the outlet of the creek.

Wooden bulkheads and jetties have been built at different times for the protection and preservation of the beach on Long Point and Beach Point.

A stone bulkhead, about 1,000 feet in length, has been completed for the protection and preservation of the outer end of Long Point, the light-house, and three-gun battery.

A dike (272 feet in length) was built in 1871–'72 across the head of Lancey's Harbor, near Abel Hill.

Beach-grass planted on Beach Point, Long Point, Abel Hill, Cove Section, and Oblique Section, and at the last two places brush has also been laid for their further protection.

The projected extension of the several jetties on Beach Point and State Dike has been completed.

A bulkhead and 6 jetties built for the preservation and protection of the beach at Cove Section, near High Head, were encroached upon by the extraordinary gales of November, 1873, and January, 1874. This bulkhead is 607 feet in length, and the jetties have an aggregate length of 126 feet. They consist of a frame-work filled with brush and ballasted with stone, and were completed in December, 1874.

Accurate resurveys were made in 1871, '72, '73, '74, and '75 of Cove Section, Oblique Section, Beach Point, and Long Point, together with elaborate soundings and current observations in the inner harbor.

All the works projected for the *preservation and improvement* of this harbor are now *completed.*

The amount expended during the fiscal year ending June 30, 1878, has

been applied to extending the stone bulkhead on Long Point; to repairing the bulkheads and jetties at Beach Point and Cove Section, and the dikes at High Head and Abel Hill; and to planting beach-grass at Cove Section and High Head Dike.

The sum of $1,000 appropriated by act of June 18, 1878, is to be applied to the repairs of the works where necessary, including some additional work for strengthening the stone bulkhead on Long Point.

These works and all the others built for the preservation and protection of this harbor will require continuous watching and repairs, for which the additional sum of $1,000 is asked for the next fiscal year.

July 1, 1877, amount available	$3,170 67	
Amount appropriated by act approved June 18, 1878	1,000 00	
		$4,170 67
July 1, 1878, amount expended during fiscal year		3,063 38
July 1, 1878, amount available		1,107 29
Amount (estimated) required for completion of existing project		1,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880		1,000 00

(See Appendix A 13.)

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

To comply with provisions of the river and harbor act of June 18, 1878, Lieutenant-Colonel Thom has been charged with and is now engaged upon surveys and examinations at the following localities, the results of which will be duly submitted when received:

1. *Portsmouth Harbor, New Hampshire.*
2. *Scituate Harbor, Massachusetts, with a view to its adaptability as a harbor of refuge.*
3. *Charles River, Massachusetts, to the head of tide-water.*
4. *Lincolnville Harbor, Maine.*
5. *Lubec Channel, Maine.*

IMPROVEMENT OF HARBORS AND RIVERS ON THE SOUTHERN COAST OF MASSACHUSETTS AND IN RHODE ISLAND—IMPROVEMENT OF CONNECTICUT RIVER.

Officer in charge, Maj. G. K. Warren, Corps of Engineers, with Capt. D. P. Heap, Corps of Engineers, under his immediate orders.

1. *Improvement of Hyannis Harbor, Massachusetts.*—Nothing has been done at this place during the past fiscal year.

The money available will be expended in strengthening the breakwater at its base with riprap granite. To complete the projected improvement an additional appropriation of $7,000 will be required, which it is desirable should be made available as soon as practicable, in order that the work may be preserved from injury.

July 1, 1877, amount available	$42 94	
Amount appropriated by act approved June 18, 1878	3,000 00	
		$3,042 94
July 1, 1878, amount expended during fiscal year		42 94
July 1, 1878, amount available		3,000 00
Amount (estimated) required for completion of existing project		7,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880		7,000 00

(See Appendix B 1.)

2. *Improvement of Wareham Harbor, Massachusetts.*—The improvement of this harbor, which consisted in making a channel 9 feet deep at mean low-water, was completed in 1876. The mean rise of tide is 4 feet, so *that vessels drawing 13 feet* are enabled to reach the wharves.

The low price at which the work was done left about $2,000 after the completion of the improvement, with which sum a "sand-catcher" is being built on Long Beach to arrest the sand carried over it into the harbor.

No further appropriation is required unless a greater depth of channel is desired.

July 1, 1877, amount available	$2,057 74
July 1, 1878, amount expended during fiscal year	1,153 38
July 1, 1878, amount available	904 36

(See Appendix B 2.)

3. *Improvement of New Bedford Harbor, Massachusetts.*—The improvement of this harbor was completed during the fiscal year. The original project contemplated a channel of 200 feet in width, and 15 feet deep at mean low-water, from the deep water at Fair Haven to the wharves at New Bedford, at an estimated cost of $24,000. Owing, however, to the prevailing low prices of labor, &c., a channel 300 feet wide, and extending further along the harbor lines than was originally designed, has been completed at a cost of $20,000.

No further appropriation is required.

July 1, 1877, amount available	$9,654 60
July 1, 1878, amount expended during fiscal year	8,852 78
July 1. 1878, amount available	801 82

(See Appendix B 3.)

4. *Improvement of Fall River Harbor, Massachusetts.*—The removal during the fiscal year of 12,857 cubic yards of material, including bowlders of various sizes, completed the projected improvement at this harbor. The channel is now 160 feet wide and 12 feet deep at mean low-water, with an additional width of 100 feet for a depth of 11 feet at the same stage of tide.

The estimated cost of this improvement was $45,000; but owing to the low price at which labor, &c., was obtained, it was completed for the sum of $30,000.

July 1, 1877, amount available	$10,256 47
July 1, 1878, amount expended during fiscal year	10,256 47

(See Appendix B 4.)

5. *Improvement of Taunton River, Massachusetts.*—There being no funds available for the improvement of this river nothing was done during the fiscal year.

A channel of 60 feet in width and 9 feet in depth at mean high-water practically exists as far as Weir, through the portion of the river for which improvement was projected.

It is proposed to expend the appropriation of $2,000 made by the act of June 18, 1878, in removing bowlders from the sides and bottom of this channel. To complete the improvement previously estimated for will require an additional appropriation of $3,000.

July 1, 1877, amount available	$100 93	
Amount appropriated by act approved June 18, 1878	2,000 00	
		$2,100 93
July 1, 1878, amount expended during fiscal year		100 93
July 1, 1878, amount available		2,000 00
Amount (estimated) required for completion of existing project		3,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880		3,000 00

(See Appendix B 5.)

6. *Improvement of Pawtucket or Seekonk River, Rhode Island.*—No work has been done during the fiscal year, and none will be done this season unless the shoals become troublesome or the channel is accidentally obstructed.

July 1, 1877, amount available	$1,511 28
July 1, 1878, amount expended during fiscal year	127 75
July 1, 1878, amount available	1,383 53

(See Appendix B 6.)

7. *Improvement of Providence River and Narragansett Bay, Rhode Island.*—The project for this improvement consists in making a wide channel, with a central depth of 23 feet at mean low-water, from Providence to the sea, at an estimated cost of about $500,000. (See special report in Appendix B 7.)

The present ruling depth is about 14 feet, the mean rise of the tide being about 4.7 feet.

It is proposed to expend the appropriation of $50,000 made by the act of June 18, 1878, in dredging a channel 23 feet deep at mean low-water to such width as the means at hand will allow—not exceeding, however, 200 feet.

The appropriation of $5,000 contained in the same act for the removal of Bulkhead Rock in this river is insufficient for its removal to the required depth (23 feet), and it is proposed to reserve it until a further appropriation is made for continuing the improvement of the river, when its removal may be undertaken.

The amount required for continuing the improvement during the next fiscal year is $100,000.

Improving Providence River and Narragansett Bay:

Amount appropriated by act approved June 18, 1878	$50,000 00
July 1, 1878, amount available	50,000 00
Amount (estimated) required for completion of existing project	450,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880	100,000 00

Improving Providence River, Rhode Island. Removing Bulkhead Rock:

July 1, 1877, amount available	$74 98	
Amount appropriated by act approved June 18, 1878	5,000 00	
		$5,074 98
July 1, 1878, amount expended during fiscal year		74 98
July 1, 1878, amount available		5,000 00

(See Appendix B 7.)

8. *Improvement of Newport Harbor, Rhode Island.*—Nothing has been done here during the past fiscal year and no work is contemplated during the next.

July 1, 1877, amount available	$30 14
July 1, 1878, Amount expended during fiscal year	30 14

(See Appendix B 8.)

9. *Improvement of Block Island Harbor, Rhode Island.*—During the fiscal year there have been 25,227 tons of riprap granite put into the breakwater and 517 tons of bowlders removed from the anchorage sheltered by it.

The breakwater now extends out 1,425 feet from the shore. A detached piece 300 feet in length has been built from a point 200 feet from the head or outer end of the main work.

A contract has been made for completing the work with the above dimensions with the available funds. When this is done the harbor, for local purposes, will be completed. No further appropriation is asked for this work.

July 1, 1877, amount available	$46,978 96
July 1, 1878, amount expended during fiscal year	41,424 24
July 1, 1878, amount available	5,554 72

(See Appendix B 9.)

10. *Improvement of Pawcatuck River, Rhode Island and Connecticut.*—No work has been done here during the past fiscal year and none is contemplated during the next.

July 1, 1877, amount available	$101 97
July 1, 1878, amount expended during fiscal year	101 97

(See Appendix B 10.)

11. *Improvement of Little Narragansett Bay, Rhode Island and Connecticut.*—The improvement in this bay was begun during the fiscal year, and 4,015 cubic yards of material, including bowlders of a size less than one cubic yard, were removed by contract at a cost of 30 cents per cubic yard, and 69 cubic yards of bowlders exceeding one cubic yard in size at a cost of $5 per cubic yard.

There were also removed by hired labor 131 cubic yards of dangerous rocks.

The estimate cost of the projected improvement is $51,000, of which $15,000 has been appropriated, leaving $36,000 still to be appropriated to complete this work.

This improvement is designed to make a safe channel through the shoals, where the ruling depth is now 4½ feet at mean low-water, of not less than 7½ feet at mean low-water and 200 feet width. The mean range of the tide is about 2½ feet.

July 1, 1877, amount available	$5,000 00	
Amount appropriated by act approved June 18, 1878	10,000 00	
		$15,000 00
July 1, 1878, amount expended during fiscal year		4,320 62
July 1, 1878, amount available		10,679 38
Amount (estimated) required for completion of existing project		36,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880		36,000 00

(See Appendix B 11.)

12. *Improvement of Connecticut River, below Hartford, Connecticut.*—This improvement consists in removing shoals between Hartford and Middletown, and in deepening the water on the bar at the mouth of the river (Saybrook Bar) by means of stone jetties, the littoral current of the sound preventing any extension of the bar. During the fiscal year the bars between Hartford and Middletown were dredged so as to give a channel with 9 feet depth at mean low-water, the work being done by a dredge hired for the purpose. The wreck of the schooner E. F. Meany was removed from Saybrook Bar.

The funds remaining were insufficient for continuing work upon the jetties.

With the $30,000 appropriated by act of Congress approved June 18, 1878, it is intended to dredge the shoals between Hartford and Middletown at such places as at low-water may be found to be necessary, to dredge the bar at the mouth of Salmon River, and to extend the east jetty at Saybrook Bar to outer edge of the bar.

An additional appropriation is asked for continuing the work on Saybrook Bar and for dredging the shoals between Hartford and Middletown.

July 1, 1877, amount available	$10,713 75	
Amount appropriated by act approved June 18, 1878	30,000 00	
		$40,713 75
July 1, 1878, amount expended during fiscal year		8,569 07
July 1, 1878, amount available		32,144 68
Amount (estimated) required for completion of existing project		30,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880		30,000 00

(See Appendix B 12.)

13. *Improvement of Connecticut River above Hartford, Connecticut, and below Holyoke, Massachusetts.*—Thorough surveys have been made of this portion of the river, upon which projects for improvement with estimates of cost have been based.

The reports upon the surveys were consolidated and printed by order of the House of Representatives at the last session of Congress as Executive Document No. 101, House of Representatives, and forms Appendix B 14 of this report.

The object of the improvement heretofore attempted was to produce at Barber's Landing Bar, by dredging (through places where the natural depth was from 1½ to 2 feet), and at Scantic Bar and Strong's Island Bar, by means of wing-dams, a depth of 3 feet at low-water.

The wing-dams effected the desired result, and the depth has been permanently maintained. The dredged portions, however, have been refilled, and there exists in them at the present time at low-water a depth of 18 inches. This it is proposed to remedy by the construction of wing-dams, which will be completed during the next fiscal year.

Such improvement is desired, however, as will give an available channel at low-water for vessels drawing 6 feet, and of dimensions larger than those that now pass through the existing canal at Enfield Falls.

The rectification of the river between Hartford and Enfield Falls will form an essential part of this improvement, and an appropriation of $100,000 for commencing it is recommended by the officer in charge. The improvement of the whole portion, a distance of about 12 miles, will, it is estimated, cost about $1,000,000.

The improvement around the Enfield Falls will require a new canal and locks, at an estimated cost of about $1,000,000. The officer in charge submits an estimate for commencing it of $200,000. He considers this more urgent than the other improvement, as it would make available for navigation the medium stages of the river, which afford a navigable capacity greater than that of the existing canal.

The falls are at all times impassable.

No immediate improvement between Enfield Falls and Holyoke is required.

Connecticut River above Hartford and below Enfield Falls:

July 1, 1877, amount available	$15,562 47
July 1, 1878, amount expended during fiscal year	629 71
July 1, 1878, amount available	14,932 76

Connecticut River on or above Enfield Falls, Connecticut, and below Holyoke, Massachusetts:

July 1, 1877, amount available	$10,702 92
July 1, 1878, amount available	10,702 92
Amount (estimated) required for completion of proposed project	835,801 00

(See Appendix B 13.)

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

To comply with the provisions of the river and harbor act of June 18, 1878, Major Warren has been charged with and is now engaged upon examinations and surveys at the following localities, the results of which will be duly submitted when received:

1. *Westport Harbor, Massachusetts.*
2. *Wood's Holl, Massachusetts.*

IMPROVEMENT OF HARBORS ON LONG ISLAND SOUND.

Officer in charge, Major J. W. Barlow, Corps of Engineers.

1. *Improvement of Stonington Harbor, Connecticut.*—No appropriation for this improvement having been made for the past fiscal year, work at this harbor was suspended.

The convenience of this location as a harbor of refuge, with depth of water sufficient for any vessel that may require its protection, renders the early completion of the breakwater designed to cover the anchorage of much importance.

With the appropriation of $40,000 by the act of June 18, 1878, this work will be extended about 600 feet.

The sum of $75,000 can be profitably expended in a further extension during the next fiscal year.

July 1, 1877, amount available	$44 63	
Amount appropriated by act approved June 18, 1878	40,000 00	
		$40,044 63
July 1, 1878, outstanding liabilities		40 00
July 1, 1878, amount available		40,004 63
Amount (estimated) required for completion of existing project		166,536 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		75,000 00

(See Appendix C 1.)

2. *Improvement of Thames River, Connecticut.*—An examination of the shoals near Norwich has been made with a view to commencing their removal under the appropriation of $10,000, made at the last session of Congress.

Citizens of Norwich have petitioned the officer in charge to increase the depth to 12 feet at mean low-water. This plan, at an estimated cost of $75,000, is recommended by him.

An examination of a shoal near the new wharf at New London has also been made, and an estimate submitted for its removal.

Amount appropriated by act approved June 18, 1878	$10,000 00
July 1, 1878, amount available	10,000 00
Amount (estimated) required for completion of existing project	81,800 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.	25,000 00

(See Appendix C 2.)

3. *Improvement of New Haven Harbor, Connecticut.*—No work was done upon this improvement during the past fiscal year.

With the appropriation of $25,000 now available, the channel between Fort Hale and Long Wharf will be widened to about 325 feet, with a depth of 16 feet at mean low-water.

The commercial importance of New Haven is represented as justifying increased harbor facilities, the present ship-channel not being adequate to the growing commerce of the city.

In answer to a resolution of the House of Representatives, January 21, 1875, plans and estimates were *submitted for the enlargement* of the channel of *this harbor, and for the construction of a* breakwater from

the new light-house on Southwest Ledge to Quixe's Ledge, so as to afford secure anchorage in stormy weather for the commerce of Long Island Sound at its widest and most dangerous point and midway of its length.

Should Congress approve this project, the sum of $100,000 could be profitably expended toward its construction during the first fiscal year.

July 1, 1877, amount available	$2,612 23	
Amount appropriated by act approved June 18, 1878	25,000 00	
		$27,612 23
July 1, 1878, amount expended during fiscal year	467 61	
July 1, 1878, outstanding liabilities	200 00	
		667 61
July 1, 1878, amount available		26,944 62
Amount (estimated) required for completion of proposed project:		
Breakwater		400,000 00
Dredging		180,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880 (as revised in this office)		15,000 00

(See Appendix C 3.)

4. *Improvement of Milford Harbor, Connecticut.*—No appropriation was made for this harbor for the past fiscal year. With the balance on hand the long jetty has been repaired and a general supervision of the improvements maintained.

With the present appropriation of $10,000 the long jetty will be completed, the dredged channel widened to 100 feet and extended through the upper harbor to the Town Wharf. The officer in charge refers to previous recommendations and estimates for a substantial jetty off Welch's Point to protect the bluffs from erosion and to provide a desirable harbor of refuge. This jetty will cost $45,000, and the whole sum could be most advantageously applied during one fiscal year.

July 1, 1877, amount available	$445 84	
Amount appropriated by act approved June 18, 1878	10,000 00	
		$10,445 84
July 1, 1878, amount expended during fiscal year		313 07
July 1, 1878, amount available		10,132 77
Amount (estimated) required for completion of proposed project		45,000 00

(See Appendix C 4.)

5. *Improvement of Housatonic River, Connecticut.*—The officer in charge recommends the removal of the obstruction known as Drew's Rock, should it be found upon examination that the work can be done at a moderate expense. This is with a view to making permanent the channel through the adjoining sand-bar, which constantly re-forms by the action of eddies which are caused by that obstruction.

An appropriation of $5,000 is asked for the ensuing fiscal year for that purpose.

July 1, 1877, amount available	$17 73	
Amount appropriated by act approved June 18, 1878	5,000 00	
		$5,017 73
July 1, 1878, amount available		5,017 73
Amount that can be profitably expended in fiscal year ending June 30, 1880		5,000 00

(See Appendix C 5.)

6. *Improvement of Bridgeport Harbor, Connecticut.*—The appropriation August 14, 1876, was applied to dredging in the upper harbor, making

the channel from the steamboat wharf to the lower bridge 450 feet wide and 9 feet deep at mean low-water.

At least one-half of the present appropriation will be devoted to dredging above the bridge, with a view to making a channel 100 feet wide and 9 feet deep at mean low-water, as far as the horse-railroad bridge. With the remainder the 12-foot channel will be widened between the sound and the inner beacon.

The existing project contemplates the widening of the 12-foot channel on the outer and inner bars to 300 feet.

July 1, 1877, amount available	$9,886 95	
Amount appropriated by act approved June 18, 1878	10,000 00	
		$19,886 95
July 1, 1878, amount expended during fiscal year		9,754 22
July 1, 1878, amount available		10,132 73
Amount (estimated) required for completion of existing project		30,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880		20,000 00

(See Appendix C 6.)

7. *Improvement of Southport Harbor, Connecticut.*—With the appropriation of $5,000 made August 14, 1876, the breakwater and dike have been repaired, the material used in repairing the dike having been obtained from the channel by dredging.

The available funds were found sufficient to excavate a channel 60 feet wide and 4 feet deep, at mean low-water, from the outer beacon to above the breakwater.

The engineer officer in charge recommends an appropriation of $5,000 to widen this channel to 100 feet.

July 1, 1877, amount available		$5,063 93
July 1, 1878, amount expended during fiscal year	$3,185 19	
July 1, 1878, outstanding liabilities	1,226 05	
		4,411 24
July 1, 1878, amount available		652 69
Amount (estimated) required for completion of existing project		5,000 00

(See Appendix C 7.)

8. *Improvement of Port Jefferson Harbor, Long Island, New York.*—The east side jetty was repaired and raised to a height of 4 feet at mean high-water. A gap at the shore end was filled, and the plank fence extended farther inland.

Both jetties are now in good condition, but should be carried out to the 9-foot curve to produce their full effect.

A channel 25 feet feet wide and 8 feet deep at mean low-water was cut through the bar during the season.

The officer in charge believes that the width of this channel will be increased by the action of the currents upon completion of the jetties, but should this not be the case, owing to the heavy nature of the material of which the bar is composed, he recommends that it be widened to 100 feet by dredging.

July 1, 1877, amount available	$11,261 64	
Amount appropriated by act approved June 18, 1878	8,000 00	
		$19,261 64
July 1, 1878, amount expended during fiscal year		10,306 76
July 1, 1878, amount available		8,954 88
Amount (estimated) required for completion *of existing project*		25,000 00
Amount that can be *profitably expended in fiscal year ending June 30, 1880.*		25,000 00

(See Appendix C 8.)

9. *Improvement of Norwalk Harbor, Connecticut.*—For the want of funds this improvement has been suspended during the past two years.

The present appropriation will be applied toward the enlargement of the upper channel to a width of 100 feet and depth of 6 feet at mean low-water.

To continue this work, the officer in charge recommends an appropriation of $15,000 for the next fiscal year.

Amount appropriated by act approved June 18, 1878	$6,000 00
July 1, 1878, amount available	6,000 00
Amount (estimated) required for completion of existing project	24,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880	15,000 00

(See Appendix C 9.)

EXAMINATION AND SURVEY FOR IMPROVEMENT.

To comply with provisions of the river and harbor act of June 18, 1878, Major Barlow has been charged with and is now engaged upon survey and examination of the *Thames River, Connecticut*, the result of which will be duly submitted when received.

IMPROVEMENT OF HUDSON RIVER—REMOVAL OF OBSTRUCTIONS IN EAST RIVER, INCLUDING HELL GATE—IMPROVEMENT OF HARLEM RIVER AND EAST CHESTER CREEK, AND OF THE HARBORS OF PORT CHESTER AND RONDOUT, NEW YORK; PASSAIC AND RARITAN RIVERS, AND THE CHANNEL BETWEEN STATEN ISLAND AND NEW JERSEY; HARBORS ON LAKE CHAMPLAIN.

Officer in charge, Lieut. Col. John Newton, Corps of Engineers, who has under his immediate orders Capt. James Mercur and Lieut. J. H. Willard, Corps of Engineers.

1. *Improvement of Hudson River, New York.*—During the fiscal year a complete survey has been made of the river from the State dam at Troy to the south end of Houghtailing Island, New Baltimore, and also re-examinations after dredging by the State engineer and surveyor.

A complete hydrographic map, on scale $\frac{1}{3000}$, has been prepared in five sheets, giving the latest information of the condition of the river at the close of the season of 1877, from Troy to New Baltimore. The work done during the fiscal year has been as follows:

	Feet.
Completion of first dike, overslaugh system	2,011
Construction of second dike, overslaugh system	1,508$\frac{6}{10}$
Construction of second half-dike, overslaugh system	448
Construction of third dike, overslaugh system	2,610$\frac{1}{3}$
Construction of third half-dike, overslaugh system	637
Construction of dike at Bath	831
Construction of dike at Coeymans	174

Repairs at Hill House Island, Beacon Island, Van Wies Point, Parda Hook, and dike at Coeymans.

Dredging under State appropriation:

	Cubic yards.
Between Albany and Troy	24,833
Between Albany and New Baltimore	20,209
Amount removed to date	226,842

July 1, 1877, amount available	$36,860 42	
Amount appropriated by act approved June 18, 1878	70,000 00	
		$106,860 42
July 1, 1878, amount expended during fiscal year	36,771 39	
July 1, 1878, outstanding liabilities	89 03	
		36,860 42
July 1, 1878, amount available		70,000 00
Amount (estimated) required for completion of existing project		$95,016 47
Amount that can be profitably expended in fiscal year ending June 30, 1880.		95,016 47

(See Appendix D 1.)

2. *Removing obstructions in East River and at Hell Gate, New York, (Hallet's Point.)*—The contract with Mr. Emory R. Seward for the removal of broken rock from this reef was extended from June 30, 1877, to November 1, 1877, and from the commencement of the year to closing the contract 13,282 tons of rock were removed.

On expiration of Mr. Seward's contract, after due public notice, contract was made with the Atlantic Dredging Company for the removal of 25,000 tons of broken rock. Work was commenced in January, 1878, and at the close of the year 6,683 tons of broken rock were removed. From November 1, 1877, to December 19, 1877, the work of removing the broken rock was continued by hiring dredges and grapples by the day, and 3,293.38 tons were removed.

Flood Rock.—No work was done except to remove the shops and storehouses formerly used in the work on Hallet's Point.

The survey of this rock and the reef has been completed and plotted.

During the latter part of June, 1878, a few men were employed in getting the machinery and pumps in order preparatory to resuming active operations.

Steam-drilling scow.—Owing to want of funds, no work was done by this machine during the year.

July 1, 1877, amount available	$123,355 78	
Amount appropriated by act approved June 18, 1878	350,000 00	
		$473,355 78
July 1, 1878, amount expended during fiscal year	86,050 27	
July 1, 1878, outstanding liabilities	4,345 30	
		90,395 57
July 1, 1878, amount available		382,960 21
Amount (estimated) required for completion of existing project		2,863,127 55
Amount that can be profitably expended in fiscal year ending June 30, 1880.		600,000 00

(See Appendix D 2.)

3. *Improvement of Harlem River, New York.*—The appropriation for this work was made June 18, 1878, and the act contains a proviso that it is not available until the right of way is secured to the United States free of cost. Negotiations to that end are now in progress.

Amount appropriated by act approved June 18, 1878	$300,000 00
July 1, 1878, amount available	300,000 00
Amount (estimated) required for completion of existing project	1,700,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880	700,000 00

(See Appendix D 3.)

4. *Improvement of Passaic River, New Jersey.*—From the commencement of the fiscal year to January, 1878, work was continued in clearing the channels from loose stones and dredging a shoal near the Erie Railroad bridge.

With the appropriation of June 18, 1878, it is proposed to continue

the clearing the channel of loose stones, and to drill and blast a number of large bowlders.

July 1, 1877, amount available	$8,565 46	
Amount appropriated by act approved June 18, 1878	10,000 00	
		$18,565 46
July 1, 1878, amount expended during fiscal year		7,956 54
July 1, 1878, amount available		10,608 92
Amount (estimated) required for completion of existing project		13,924 00
Amount that can be profitably expended in fiscal year ending June 30, 1880		5,000 00

(See Appendix D 4.)

5. *Improvement of East Chester Creek, New York.*—The work under contract on the cut 100 feet wide and about 2,200 feet long was completed.

The following work not included in the contract was done by hired labor: 14,855 cubic yards of mud, clay, and bowlders removed from the cut near the bridge on the Boston road, and 16,235 cubic yards from the west bank of the channel opposite Goose Island.

July 1, 1877, amount available	$29,718 87	
Amount appropriated by act approved June 18, 1878	10,000 00	
		$39,718 87
July 1, 1878, amount expended during fiscal year		29,707 12
July 1, 1878, amount available		10,011 75
Amount (estimated) required for completion of existing project		89,500 00
Amount that can be profitably expended in fiscal year ending June 30, 1880		10,000 00

(See Appendix D 5.)

6. *Improvement of Port Chester Harbor, New York.*—No appropriation having been made for this work, no work was done during the year.

July 1, 1877, amount available	$2,200 00
July 1, 1878, amount expended during fiscal year	250 00
July 1, 1878, amount available	1,950 00
Amount (estimated) required for completion of existing project	84,632 00

(See Appendix D 6.)

7. *Improvement of harbor at Rondout, New York.*—The branch dike, 883 feet long, was completed September 12, 1877, and the south dike, 893.6 feet long, June 1, 1878.

A fender of pile-work has been placed around the junction of the north and south dikes to protect it from collisions by vessels entering the harbor.

Spring-piles were driven along the face of the north, branch, and south dikes to mark their location at high-water.

July 1, 1877, amount available	$23,289 77	
Amount appropriated by act approved June 18, 1878	30,000 00	
		$53,289 77
July 1, 1878, amount expended during fiscal year		18,786 24
July 1, 1878, amount available		34,503 53

(See Appendix D 7.)

8. *Improvement of channel between Staten Island and New Jersey.*—No work has been done during the year, as the efforts to ascertain from those most largely interested in the improvement of this channel what, in their opinion, the needs of commerce require have not resulted in anything satisfactory enough to warrant the expenditure of the funds *available.*

July 1, 1877, amount available	$10,229 74	
Amount appropriated by act approved June 18, 1878	15,000 00	
		$25,229 74
July 1, 1878, amount expended during fiscal year		5 00
July 1, 1878, amount available		25,224 74
Amount (estimated) required for completion of existing project		15,480 00
Amount that can be profitably expended in fiscal year ending June 30, 1880		15,000 00

(See Appendix D 8.)

9. *Improvement of Raritan River, New Jersey.*—The appropriation for this work having been made so near the close of the fiscal year, there is no work to report.

Amount appropriated by act approved June 18, 1878	$200,000 00	
		$200,000 00
July 1, 1878, amount available		200,000 00
Amount (estimated) required for completion of existing project		1,893,662 05
Amount that can be profitably expended in fiscal year ending June 30, 1880		200,000 00

(See Appendix D 9.)

10. *Improvement of Echo Harbor, New Rochelle, New York.*—The appropriation for this work having been made so near the close of the fiscal year, there is no work to report.

Amount appropriated by act approved June 18, 1878	$10,000 00
July 1, 1878, amount available	10,000 00
Amount (estimated) required for completion of existing project	28,955 38
Amount that can be profitably expended in fiscal year ending June 30, 1880	10,000 00

(See Appendix D 10.)

11. *Improvement of Plattsburg Harbor, New York.*—Repairs have been made to the breakwater by filling empty places with stone, and the bar extending easterly from the face of the south wharf has been removed, the depth of water having been increased to 8 feet; 1,073 cubic yards of silt, sand, clay, and stone have been dredged, and 525 cubic yards of rubble stone applied to the repairs of the breakwater.

July 1, 1877, amount available	$4,941 52	
July 1, 1878, amount expended during fiscal year	3,961 03	
July 1, 1878, amount available		980 49
Amount (estimated) required for dredging		5,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880		5,000 00

(See Appendix D 11.)

12. *Improvement of harbor of Burlington, Vermont.*—The repairs to the southern end of the breakwater have been completed.

A crib, 28 feet long and of the required height for filling the gap near the southern end, has been constructed by hired labor and sunk in position.

The exterior face of the old breakwater for about 1,100 feet has been repaired.

The portion of the northern breakwater of 200 feet has been repaired and the superstructure reconstructed.

July 1, 1877, amount available	$15,477 15	
Amount appropriated by act approved June 18, 1878	20,000 00	
		$35,477 15
July 1, 1878, amount expended during fiscal year		12,717 50
July 1, 1878, amount available		22,759 65
Amount (estimated) required for completion of *existing project*		275,000 00
Amount that can be profitably *expended in fiscal year ending June 30,* 1880		50,000 00

(See Appendix D 12.)

13. *Improvement of harbor at Swanton, Vermont.*—No work has been done during the year. The breakwater was seriously injured by ice floes during the prevalence of a heavy northwesterly storm in the month of March last. With the appropriation of June 18, 1878, it is proposed to repair these and to continue the extension of the breakwater in a northwesterly direction.

July 1, 1877, amount available	$2,610 65	
Amount appropriated by act approved June 18, 1878	20,000 00	
		$22,610 65
July 1, 1878, amount expended during fiscal year		10 15
July 1, 1878, amount available		22,600 50
Amount (estimated) required for completion of existing project		217,160 00
Amount that can br profitably expended in fiscal year ending June 30, 1880		20,000 00

(See Appendix D 13.)

14. *Improvement of Otter Creek, Vermont.*—No operations were conducted during the year for want of funds.

With the appropriation of June 18, 1878, it is proposed to resume work on the improvement of the channel and of Vergennes Basin.

July 1, 1877, amount available	$55 84	
Amount appropriated by act approved June 18, 1878	8,000 00	
		$8,055 84
July 1, 1878, amount expended during fiscal year		5 00
July 1, 1878, amount available		8,050 84
Amount (estimated) required for completion of existing project		35,146 00
Amount that can be profitably expended in fiscal year ending June 30, 1880		20,000 00

(See Appendix D 14.)

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

In answer to resolutions of House of Representatives, Lieutenant-Colonel Newton, during the fiscal year, submitted to this office reports upon examinations made at the following localities:

1. *Coast of Long Island, between Rockaway Inlet and Coney Island.* (See Appendix D 15.)
2. *Junction of Newtown Creek and East River, New York.* (See Appendix D 16.)
3. *Flushing Bay, New York.* (See Appendix D 17.)

As no funds were available for these examinations, the reports were necessarily made from the best sources of information attainable.

To comply with the provisions of the river and harbor act of June 18, 1878, Lieutenant-Colonel Newton has been charged with and is now engaged upon examinations and surveys at the following localities, the results of which will be duly submitted when received:

1. *Flushing Bay, New York.*
2. *The coast of Long Island, New York, between Coney Island Point and Rockaway Inlet, in New York Bay.*
3. *Sheepshead Bay, New York.*
4. *Canarsie Bay, New York.*
5. *East River, New York, at its junction with Newtown Creek.*

CONSTRUCTION OF PIER AT LEWES, DELAWARE—HARBOR IMPROVEMENTS ON DELAWARE RIVER AND BAY—IMPROVEMENT OF THE NAVIGATION OF DELAWARE AND SCHUYLKILL RIVERS; OF BROADKILN RIVER, DELAWARE; AND OF SHREWSBURY RIVER AND COHANSEY CREEK, NEW JERSEY—DELAWARE BREAKWATER HARBOR.

Officers in charge, Lieut. Col. J. D. Kurtz, Corps of Engineers, until his death, October 16, 1877, since which time Col. J. N. Macomb, Corps of Engineers.

Capt. William Ludlow, Corps of Engineers, has, during the fiscal year, been under the immediate orders of the officers in charge of these works.

1. *Construction of pier near Lewes, Delaware.*—During the past season 30 piles and their attachments have been placed in position, which includes the 79th row, and extended the pier 126 feet, making the whole length of the pier 1,659 feet.

The superstructure was somewhat delayed in its construction, owing to proposed modifications in the plan of construction for the pier-head, in order to adapt it fully to its intended use.

Various tests have been made of the sustaining capacity of the piles now in position, and the stability of the gravel stratum, the result being quite satisfactory.

In view of the deterioration of implements and machinery, owing to delay in the work for want of sufficient appropriations, it is estimated that the pier cannot be completed for less than $35,000, which sum can be advantageously expended in the fiscal year ending 30th June, 1880.

July 1, 1877, amount available	$20,821 63	
Amount appropriated by act approved June 18, 1878	20,000 00	
		$40,821 63
July 1, 1878, amount expended during fiscal year		20,820 54
July 1, 1878, amount available		20,001 09
Amount (estimated) required for completion of existing project		35,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880		35,000 00

(See Appendix E 1.)

2. *Improving ice-harbor at New Castle, Delaware.*—The coal-wharf below the harbor has been removed for a length of 110 feet in addition to that previously taken away, making 218 feet in all, and a substantial head has been built on the part remaining. It is thought that enough of this obstruction has now been removed to prevent any further ill effects from it on the harbor.

The crib-foundation for the new ice-pier, the last contemplated by the present plan of improvement, has been completed in readiness for the stone superstructure, and it is proposed to apply the amount appropriated for the ensuing year in building up the stone work as far as practicable.

Next year it is proposed to complete the pier and dredge out the accumulated sediment in the lower part of the harbor, for which purpose an appropriation of $18,500 is asked.

July 1, 1877, amount available	$14,418 27	
Amount appropriated by act approved June 18, 1878	10,000 00	
		$24,418 27
July 1, 1878, amount expended during fiscal year		14,418 27
July 1, 1878, amount available		10,000 00
Amount (estimated) required for completion of existing project		18,500 00
Amount that can be profitably expended in fiscal year ending June 30, 1880		18,500 00

(See Appendix E 2.)

3. *Improving harbor at Wilmington, Delaware.*—During the past year operations have been directed to the removal of fast-rock from the channel just below Third street, and the removal of mud from the channel between the Christiana Iron Company's wharf and Brandywine Creek. The width of the channel has been increased in each case, affording 13 feet depth of water at the former and 12 feet at the latter point of low tide.

The present season it is proposed to remove 24,000 cubic yards of mud from the channel between the light-house buoy depot and mouth of Brandywine; about 68 cubic yards of rock from the channel just above and below Third street.

Next season it is proposed to remove, by dredging along the channel between the Christiana Iron Company's wharf and mouth of Brandywine Creek, at a point on the south side of the channel just above the Brandywine and along the channel from opposite the Lobdell Works to near Market street, about 56,000 cubic yards of material.

This will require an appropriation of $13,000.

July 1, 1877, amount available	$12, 513 81	
Amount appropriated by act approved June 18, 1878	7, 000 00	
		$19, 513 81
July 1, 1878, amount expended during fiscal year		12, 512 66
July 1, 1878, amount available		7, 001 15
Amount (estimated) required for completion of existing project		13, 000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880		13, 000 00

(See Appendix E 3.)

4. *Improving harbor at Marcus Hook, Pennsylvania.*—No material change in the condition of this harbor has taken place during the past year.

Slight repairs are required to the top portion to the outer ice-pier on the upper line. The top portion of the two landing-piers and the connecting bridges are much in need of repairs, the timber being considerably decayed. A small quantity of earth filling is also washed off.

During the present season it will be advisable to make all necessary repairs at this work, which can be done from the existing appropriation.

July 1, 1877, amount available	$6, 342 91
July 1, 1878, amount expended during fiscal year	1, 321 15
July 1, 1878, amount available	5, 021 76

(See Appendix E 4.)

5. *Improving ice-harbor at Chester, Pennsylvania.*—There has been no material change in the condition of this harbor during the past year. No work has been done here during the fiscal year for want of funds.

The ice-piers and connecting bridges on the upper line of the harbor are in good condition. The piers and causeway on the lower line of the harbor need repairs, and a bridge to connect with the outer pier will have to be rebuilt.

By act of Congress, approved June 18, 1878, $3,400 were appropriated for improving this harbor.

During the present season it is proposed to make necessary repairs to the piers and causeway on the lower line, and rebuild the bridge to connect with the outer pier.

Amount appropriated by act approved June 18, 1878	$3, 400 00
July 1, 1878, amount available	3, 400 00

(See Appendix E 5.)

6. *Improving Schuykill River, Pennsylvania.*—During the past year operations for improving this river have been confined along the channel from the mouth up stream to opposite the outlet of Back Channel, and along the channel in the vicinity of Gibson's Point, the improvement at the former locality being with a view of deepening the channel to 24 feet at low tide. About 50,000 cubic yards have been removed. At the latter point about 17,000 cubic yards have been removed, obtaining 20 feet depth of water at low tide.

The present season it is proposed to continue the dredging in the vicinity of the mouth, advancing up stream to near the Girard Point grain-elevator, just above Penrose Ferry bridge; along the channel between Point Breeze and Gibson's Point; and removal of rock obstructions off "Gibson's." This will require the removal of about 135,100 cubic yards of material.

Next year it is proposed to complete the deep-water channel from the mouth up stream toward Girard Point; continue the improvement along the channel between Point Breeze and Gibson's Point; along the channel off "Gibson's," and above toward Gray's Ferry bridge. This will require the removal of 100,000 cubic yards of mud between the mouth and Girard Point; 20,000 cubic yards coarse material between Point Breeze and "Gibson's;" 300 cubic yards of rock off "Gibson's" and about 50,000 cubic yards of sand and gravel between "Gibson's" and Gray's Ferry bridge; the latter work to be executed with a view of affording 18 feet depth of water at low tide.

July 1, 1877, amount available	$14,003 79	
Amount appropriated by act approved June 18, 1878	30,000 00	
		$44,003 79
July 1, 1878, amount expended during fiscal year		13,680 01
July 1, 1878, amount available		30,323 78
Amount (estimated) required for completion of existing project		179,700 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		50,000 00

(See Appendix E 6.)

7. *Improving Delaware River below Petty's Island.*—During the past year the work of improving this river was continued at Fort Mifflin Bar, increasing the width of channel, and the depth to 22 feet at low water; about 62,000 cubic yards of material were removed.

The wreck of sloop Spray was removed from the channel just above Pea Patch Island, Fort Delaware.

Examinations and surveys are now in progress to ascertain the character and extent of work to be done before submitting a project for the application of the amount, appropriated June 18, 1878, for this river.

July 1, 1877, amount available	$25,836 05	
Amount appropriated by act approved June 18, 1878, for improving Delaware River below Bridesburg, Pennsylvania..	100,000 00	
		$125,836 05
July 1, 1878, amount expended during fiscal year		19,695 20
July 1, 1878, amount available		106,140 85

(See Appendix E 7.)

8. *Improving Delaware River between Trenton and White Hill, New Jersey.*—No work has been done at this locality since operations ceased in the fall of 1875 for want of funds. A channel had then been made along the north and east side of Periwig Island, 125 feet in width and 6 feet depth of water at low tide.

Congress, at its last session, appropriated *$10,000* for continuing the improvement *of the river at this locality.*

It is proposed to make examinations along the channel of the river, to ascertain the character and extent of the obstructions, previous to submitting a project for executing the work.

Amount appropriated by act approved June 18, 1878	$10,000 00
July 1, 1878, amount available	10,000 00
Amount (estimated) required for completion of existing project	20,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880	20,000 00

(See Appendix E 8.)

9. *Improving Broadkiln River, Delaware.*—Operations for the improvement of this river ceased in the spring of 1874.

Should an appropriation be made, it is proposed next year to continue the work by dredging the river at the shoal places and excavating an inlet into the bay at the junction of the Broadkiln and Lewes Creeks.

Amount (estimated) required for completion of existing project	$70,447 00

(See Appendix E 9.)

10. *Improving the north and south branches of Shrewsbury River, New Jersey.*—No work has been done for the improvement of this river since 1873.

During the present season it is proposed to make a thorough survey of the river, in order to prepare a project for the application of the sum appropriated June 18, 1878.

Amount appropriated by act approved June 18, 1878	$18,000 00
July 1, 1878, amount available	18,000 00

(See Appendix E 10.)

11. *Improving Cohansey Creek, New Jersey.*—No appropriation has been made for this work for the last four years.

It is proposed to expend the amount appropriated June 18, 1878, in deepening and widening the channel according to the original project.

For continuing this improvement an appropriation of $15,000 is asked for the next fiscal year.

Amount appropriated by act approved June 18, 1878	$5,000 00
July 1, 1878, amount available	5,000 00
Amount (estimated) required for completion of existing project	15,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880	15,000 00

(See Appendix E 11.)

12. *Improving channel of Salem River, New Jersey.*—No work has been done for the improvement of this river since 1871.

Previous to making a project for the application of the sum appropriated June 18, 1878, it is proposed to make an examination at the mouth of the river to determine the extent and character of the obstructions and the best method of their removal.

Amount appropriated by act approved June 18, 1878	$3,000 00
July 1, 1878, amount available	3,000 00

(See Appendix E 12.)

13. *Delaware Breakwater.*—There has been no material change in the condition of this work since the last annual report.

The use of the harbor as a port of call for transatlantic shipping is largely increasing, as will be seen by the tabular statement in the appendix.

(See Appendix E 13.)

14. *Port Wardens' Line, Philadelphia, Pennsylvania.*—This question remains as last reported.

(See Appendix E 14.)

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

To comply with provisions of the river and harbor act of June 18, 1878, Colonel Macomb has been charged with and is now engaged upon surveys and examinations at the following localities, the results of which will be duly submitted when received:

1. *The Mispillion Creek, Delaware.*
2. *The Salem River, New Jersey, between Sharpstown and Delaware Canal.*
3. *Woodbridge Creek, Middlesex County, New Jersey.*
4. *Elizabeth River, New Jersey.*
5. *Rahway River, New Jersey.*
6. *Manasquan River, New Jersey.*
7. *Duck Creek, Delaware.*
8. *The Delaware River below League Island.*

IMPROVEMENT OF HARBORS AND RIVERS OF CHESAPEAKE BAY, MARYLAND; OF JAMES AND APPOMATTOX RIVERS, VIRGINIA; OF GREAT KANAWHA RIVER, WEST VIRGINIA; OF NEW RIVER, VIRGINIA AND WEST VIRGINIA, AND OF CAPE FEAR RIVER, NORTH CAROLINA.

Officer in charge, Maj. William P. Craighill, Corps of Engineers, having under his immediate orders Capts. J. W. Cuyler and C. B. Phillips, and Lieut. Thomas Turtle, Corps of Engineers.

During the absence of Major Craighill on duty in Europe, from February 27 to the end of the fiscal year, he was temporarily relieved by Captain Cuyler of the improvement of New River, and of the remaining improvements in his charge by Captain Phillips.

1. *Improvement of Chester River at Kent Island Narrows, Maryland.*—At the date of the last annual report, the original project for this improvement, which was to dredge a channel 100 feet in width and 7 feet in depth at ordinary low water from Easton Bay to Chester River, had been carried out, except that the channel on the Easton Bay side, as well as about two-fifths of the length of the channel on the Chester River side of the Kent Island Causeway, had been completed to only 80 feet in width. The passage through the causeway had also been cut to the full width (60 feet) allowed by the draw; and additional vent had been provided for the current by cutting away the causeway under the counterpoise of the draw, and the introduction by the county authorities of one span of pile bridge next to the draw abutment.

From an examination of the channel made shortly before the date of the last annual report, it was ascertained that while the channel generally was standing well, a shoaling was taking place immediately below the causeway, on the Easton Bay side, due to the change of the current caused by cutting a passage through the causeway. As this current was found to be setting directly across a point of shoals below the draw, it was determined to abandon the old channel around the point and make a new and direct one across the shoal, the distance across this point between the 7-foot contours being about 600 feet.

Dredging at the point below the draw was commenced and continued until a channel 600 feet in length, 75 feet in width, and 7 feet in depth at ordinary low-water had been completed across the point. The dredge was then removed to the Chester River side of the causeway for the purpose of widening portions of the channel, particularly at the abrupt turn from the narrows into Chester River. On the 26th of September operations were suspended, the *appropriation having become* exhausted.

At a late examination of the new cut across the point below the causeway, it was found that some shoaling had taken place, and that not over 6 feet could be carried across at low-water. This shoaling appears to be due to the large amount of scour at the draw. When this scouring ceases, it is probable that the cut below will remain permanently open.

The passage through the narrows is now used by sailing-vessels, but rarely by steamers. It is believed that when the route is better known its use by steamers will be adopted.

The original estimate for this work was $23,000. Twenty-eight thousand dollars was appropriated in all up to June 30, 1878, of which amount $3,000 remains unexpended. This balance will be sufficient to nearly carry out the original project, which will have cost more than the original estimate by reason of long and unavoidable delays.

July 1, 1877, amount available	$4,033 23	
Amount appropriated by act approved June 18, 1878	3,000 00	
		$7,033 23
July 1, 1878, amount expended during fiscal year		4,028 40
July 1, 1878, amount available		3,004 83

(See Appendix F 1.)

2. *Improvement of the harbor at Baltimore, Maryland.*—The object of this work has been to secure, by dredging, a channel sufficient to accommodate vessels drawing 22½ or 23 feet. The requisite depth for this purpose was secured in 1874, but the desired width has not yet been obtained. The appropriations since that time have been only slightly in excess of the amount required for annual reparations, but the excess has been constantly applied to securing additional width.

During the past fiscal year, dredging has been carried on at the lower end of the Brewerton Channel to restore the depth of channel as far up as opposite North Point, and at the angle formed by the intersection of the Brewerton and Craighill Channels to facilitate the passage of vessels from one channel to the other.

This dredging was done by contract, and although much delayed, owing to the insufficiency of the contractors' machinery, was carried through to completion in June, thus restoring a depth in the Brewerton Channel of 25 feet at mean low-water over the entire width of channel, from its lower end to a point opposite North Point, and taking off a large triangular piece at the angle formed by the intersection of the Brewerton and Craighill Channels, which area was also dredged to a depth of 25 feet at mean low-water.

On the completion of this work an entirely new cut was commenced on the west side of the Brewerton Channel, and carried as far as available funds would permit.

The total amount of material removed during the year under the contract was 300,145 cubic yards.

A careful examination of the dredged area was made in June after the close of the dredging.

Extensive repairs to the tug Leslie were made during the winter months. A new boiler was put in, the machinery thoroughly overhauled, a new pilot-house built, and a new propeller put on.

An appropriation of $75,000 has been made for the fiscal year ending June 30, 1879, leaving $110,000 yet needed to complete the existing project. To this sum add $50,000 for estimated amount required for reparations, and there remains as the amount that can be profitably expended in the fiscal year ending June 30, 1880, $160,000.

July 1, 1877, amount available	$55,528 96	
Amount appropriated by act approved June 18, 1878	75,000 00	
		$130,528 96
July 1, 1878, amount expended during fiscal year		54,118 46
July 1, 1878, amount available		76,410 50
Amount (estimated) required for completion of existing project		160,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		160,000 00

(See Appendix F 2.)

3. *Improvement of Wicomico River, near Salisbury, Maryland.*—The original project for this work was, as stated in the last annual report, so modified on account of limited means as to contemplate the dredging of a channel only 50 feet in width and 5 feet in depth at ordinary low-water. This was completed in January, 1876, except that the channel for a distance of 300 feet was left but 28 feet wide.

With the appropriation of $5,000 made for this work by act of August 14, 1876, the channel throughout its entire length, a distance of 7,000 feet, has been widened to 70 feet, with a depth of 5 feet at ordinary low-water, and the turning-basin near the town excavated to the same depth, with as large an area as the safety of the wharves on either side would permit.

At the close of operations a careful examination of the entire channel and turning-basin was made; the examination showed that the dredging had been well executed.

The longitudinal dikes below the town became somewhat damaged during the past year. These dikes have been repaired as thoroughly as the limited state of available funds would permit.

The deposition of sawdust from the mills above has now been altogether abandoned, thus removing the principal cause of the rapid filling of the turning-basin.

The appropriations for this work have been June 10, 1872; March 3, 1873; June 23, 1874; March 3, 1875; August 14, 1876; and June 18, 1878. Total, $30,000.

Should the original plan be carried out, an appropriation of $10,000 will still be required.

July 1, 1877, amount available	$4,700 70	
Amount appropriated by act approved June 18, 1878	5,000 00	
		$9,700 70
July 1, 1878, amount expended during fiscal year		4,665 70
July 1, 1878, amount available		5,035 00
Amount (estimated) required for completion of existing project		10,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		10,000 00

(See Appendix F 3.)

4. *Improvement of James River, Virginia.*—The operations of the year have been conducted in furtherance of the existing project for the improvement of this river, and have consisted principally in the removal of the rock by blasting, dredging, and the construction of wing-dams.

On the 1st of July, 1877, the amount available for this work being but $17,000 (the balance of the appropriation of August 14, 1876), the period of active operations extended only from July 1 to October 31. Since the latter date no work (exclusive of surveys) has been done by the United States.

During the above-mentioned period 166 cubic yards of rock were removed from Rockett's Reef; 10,920 cubic yards of material were dredged

from Richmond Bar and Randolph's Flats, and 3,350 linear feet of wing-dams were constructed between Richmond Bar and Warwick Bar.

The city of Richmond has continued to co-operate with the United States in improving the channel. The operations of the city have been mostly confined to dredging at Drury's Island Cut, Richmond Bar, Randolph's Flats, and Warwick Bar.

That portion of the machinery used for blasting and removing rock belongs to the United States. The remaining portion of the machinery, used for dredging, pile-driving, &c., belongs to the city of Richmond, and was hired by the United States, the latter paying as rental the actual cost of repairs while in its service.

While the operations of the year have been but limited, the results have, on the whole, been satisfactory. With the exception of two short distances, 16 feet can now be found, at ordinary high-water, from Rockett's Reef to the sea. At the excepted points but 15 feet are to be found; but it is believed that by a judicious contraction of the river at these points the desired 16 feet may be obtained and maintained without further dredging.

The number and size of vessels trading to this port are constantly increasing, and a greater width and depth of channel is requisite for the wants of commerce.

The aim of this improvement is to secure a channel 180 feet in width and 18 feet in depth.

There was left of estimate to be provided for at date of last annual report..		$258,024 00
Appropriated by act approved June 18, 1878.....		70,000 00
Leaving yet to be provided for.....		188,024 00
July 1, 1877, amount available	$16,902 92	
Amount appropriated by act approved June 18, 1878.....	70,000 00	
		86,902 92
July 1, 1878, amount expended during fiscal year.....		16,890 98
July, 1, 1878, amount available.....		70,011 94
Amount (estimated) required for completion of existing project.....		188,024 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		150,000 00

(See Appendix F 4.)

5. *Improving Appomattox River, below Petersburg, Virginia.*—The balance ($15,000) of the appropriation of August 14, 1876, has been expended during the past year between the city of Petersburg and the upper end of Puddledock Cut.

This portion of the river has necessarily been somewhat neglected of late years, the greater portions of the appropriations having been absolutely required for dredging Puddledock Cut, and the construction of deflectors and embankments in connection with it.

The work of the year has consisted principally of the removal by blasting of 421 cubic yards of rock from the channel, at the bend opposite Stein's upper cut; the construction of 812 linear feet of longitudinal dikes, extending down stream on the south shore from Lieutenant's Run; and the construction of thirteen wing-dams, composed partly of sheet-piling and partly of stakes and brush wattling, located for the most part at the long straight reach occupied by Page's Bar.

These jetties contract the river to a general width of 140 feet, but more contraction will be needed probably when the remaining jetties come to be extended.

An appropriation of $30,000 was made by the act of June 18, 1878,

for the fiscal year ending June 30, 1879; $83,000 were required to complete the project which was in existence on June 30, 1875; $53,000 yet remain to be provided for.

July 1, 1877, amount available	$15,571 09	
Amount appropriated by act approved June 18, 1878	30,000 00	
		$45,571 09
July 1, 1878, amount expended during fiscal year		15,565 90
July 1, 1878, amount available		30,005 19
Amount (estimated) required for completion of existing project		53,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880		30,000 00

(See Appendix F 5.)

6. *Improvement of Great Kanawha River, West Virginia.*—The sites for a new lock and dam, to be designated as No. 3 of the Kanawha series, were acquired during the autumn of 1877. The lock is to be located on the right bank, at the foot of Paint Creek Shoal. Work at Lock No. 3 was commenced in February last, and is being carried on by hired labor and the purchase of material in open market.

Work at Lock No. 4, near Cabin Creek Shoal, has been carried on under contract. Progress has been slower than was anticipated, owing to the financial difficulties of the contractor.

The contractors at Dam No. 4 have failed to carry out their contract for the construction of a dam, abutment, pier, and floor of a navigation pass adjoining Lock No. 4. They abandoned their work in December, 1877, and the contract was annulled on the 31st of January, 1878. The work at this locality has since been carried on by hired labor and purchase of material in open market. A contract has been made for the iron-work of the pass and wier of Dam No. 4.

Work at Lock No. 5, near Brownstown, has been carried on under contract. The work has been delayed somewhat by occasional strikes of the laborers. A contract has been made for the construction of iron gates for Lock No. 5.

Work at Dam No. 5 has been carried on under contract for the construction of dam, abutment, pier, and floor of a navigation pass adjoining Lock No. 5. The masonry of the abutment and pier has all been laid, and the placing and embanking of coffer-dam for pass is in progress.

The iron-work of the pass and weir has all been delivered at the site.

In continuation of the plan of temporarily improving portions of the river not affected by the permanent works, a small sum has been expended in removing bowlders from that portion of the river between Knob Shoal and Emory's Dam, a distance of about 6 miles, and in repairing a break in "Two-mile Dam," caused by a freshet in November, 1877.

Surveys have been made below Charleston, with a view to establishing the proper locations of locks at the lower portion of the river.

The state of the river has been much more favorable for successful operations during the fiscal year just ended than during the year previous. The working season of 1877 was, until October, unusually favorable.

During the month of June last labor troubles seriously interfered with operations at all the works upon the river. These troubles were caused by strikes among the contractors' laborers.

The appropriations have been: March 3, 1873, $25,000; June 23, 1874,

$25,000 (expended in temporary improvement); March 3, 1875, $300,000; August 14, 1876, $270,000; June 18, 1878, $222,000.

July 1, 1877, amount available	$447,584 64	
Amount appropriated by act approved June 18, 1878	222,000 00	
		$669,584 64
July 1, 1878, amount expended during fiscal year	189,700 77	
July 1, 1878, outstanding liabilities	19,803 43	
		209,504 20
July 1, 1878, amount available		460,080 44
Amount (estimated) required for completion of existing project		3,600,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880		500,000 00

(See Appendix F 6.)

7. *Improvement of the Cape Fear River, North Carolina.*—The work of the year has consisted principally in the continued deposit of stone upon the closing work at the New Inlet.

The contract for the delivery of 45,000 cubic yards of stone, which was being executed at the date of the last annual report, was completed on the 5th of January, 1878. Forty-nine thousand one hundred and twenty-nine cubic yards were delivered under this contract, 28,725 yards of which since July 1, 1877.

Another contract was entered into November 24, 1877, for the delivery of about 12,000 cubic yards of stone, the delivery to be completed by April 30, 1878. On the 6th of April 11,715 cubic yards had been delivered, when the contract was closed and work suspended on account of the near exhaustion of available funds.

Total amount of stone deposited upon the dike during the past fiscal year, 40,440 cubic yards.

The stone was distributed quite uniformly over the entire length of the work until it was all brought up gradually to low-water mark.

After this the work was filled to high-water in the shape of a ridge, to distances of 850 and 650 feet from Federal and Zeke's Points respectively. The full required width has not yet been given to the structure.

Extensive hydrographic surveys have been made during the year, including New Inlet outside the closing work, Snow's Marsh Channel, and both the eastern and western channels at the old entrance to the river. Simultaneous tidal observations have also been made from time to time at various points on the river.

The only remarkable change which has taken place in the shore-lines near New Inlet has been at Zeke's Point, where the low-water line has advanced fully 300 feet on the inlet side.

The Snow's Marsh Channel and the channel at the "Logs" have remained in about the same condition as at last report.

The latter channel should be increased to 250 feet in width; it is now but 130 feet wide.

The "rip" at the western channel at old entrance to river has improved in depth during the year. The Bald Head Channel has shoaled somewhat, though the distance across the bar has been steadily diminishing. The suction-dredge, formerly in use at this bar, has remained laid up for want of funds. It is in need of extensive repairs. This or some suitable dredge should be put at work upon this bar at as early a day as possible.

An appropriation of $160,000 for this work was made by act approved June 18, 1878, which fills the estimate of June 30, 1876, for the completion of existing project. The unexpected settling of the closing work at the inlet will require the deposition of nearly 50,000 cubic yards of

stone more than was at first anticipated, which will increase the estimate of 1876 by about $100,000.

July 1, 1877, amount available	$91,788 60	
Amount appropriated by act approved June 18, 1878	160,000 00	
		$251,788 60
July 1, 1878, amount expended during fiscal year		91,230 36
July 1, 1878, amount available		160,558 24
Amount (estimated) required for completion of existing project		100,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		50,000 00

(See Appendix F 7.)

8. *Improvement of New River, from Lead Mines in Wythe County, Virginia, to mouth of Greenbrier River, West Virginia.*—The plan adopted for the improvment of this river contemplates a channel-way 30 feet wide and 2 feet deep below the lowest water, suited for the keel-boats now in use, but at the same time capable of utilization and adaptation, at some future day, in a further improvement of the navigation for light steamboats, should means be provided therefor.

The season's work was commenced at the bridge of the Atlantic, Mississippi, and Ohio Railroad, and carried continuously upstream toward the lead mines, 9 miles, as far as Falls Branch Falls, resulting in the removal of all obstructions in that portion of the river to the adopted depth and width. The work was done by hired labor, and the purchase of material in open market.

The ledges and detached bowlders were blasted out under water, and the *débris* scoured out of the channel and built into the facings and heads of the wing-dams and training-walls; the gravel shoals were excavated through, and materials made into the heartings of these constructions. By these means sluices and chutes, affording an unobstructed water-way, were made, without increasing insurmountably the velocity and volume of the water in them. The plan adopted has proved its capability to accomplish its design. It is, therefore, proposed, during the ensuing year, to continue it, with slight modifications, working still up the river, but on an enlarged scale, so as to open up fully another 10 miles of river.

July 1, 1877, amount available	$14,921 75	
Amount appropriated by act approved June 18, 1878	15,000 00	
		$29,921 75
July 1, 1878, amount expended during fiscal year		6,492 26
July 1, 1878, amount available		23,429 49
Amount (estimated) required for completion of existing project		70,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		35,000 00

(See Appendix F 8.)

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

To comply with provisions of the river and harbor act of June 18, 1878, Major Craighill has been charged with and is now engaged upon examinations and surveys at the following localities, the results of which will be duly submitted when received:

1. *The peninsula of Maryland and Delaware, with a view to a construction of a ship-canal to connect the waters of the Delaware and Chesapeake Bays.*

2. *The bars at the entrance of Annapolis Harbor, Maryland, with a view to accommodation of deep-draught vessels at low tide.*

3. *West branch of Patapsco River, Maryland, from Light-street* bridge

to head of tide-water, and an estimate of the cost of making the same navigable for canal-boats.

4. *New River, from the lead mines in Wythe County to the mouth of Wilson, in Grayson County, Virginia.*

IMPROVEMENT OF THE HARBORS OF WASHINGTON AND GEORGETOWN, DISTRICT OF COLUMBIA; OF TRIBUTARIES OF THE LOWER POTOMAC; OF RAPPAHANNOCK, ELIZABETH, AND NANSEMOND RIVERS, VIRGINIA; AND OF RIVERS IN NORTH CAROLINA—IMPROVEMENT OF NORFOLK HARBOR.

Engineer in charge, S. T. Abert, United States Civil Engineer.

1. *Harbors of Washington and Georgetown, District of Columbia.*—Operations remained suspended during the greater part of the fiscal year for want of funds. The channel excavated in 1874–'75 through the bar between Easby's Point and the Long Bridge has, as has been anticipated, gradually filled, owing to the deposit of sand brought down by freshets. In November, 1877, an unusually large freshet occurred, which seriously injured the navigation by large deposits of sand on the bar. A temporary channel was dredged by the coal-shippers and merchants of Georgetown in the spring of 1878 for the immediate relief of shipping, and the small balance remaining from the last appropriation for this work was applied to increasing the width of the channel so excavated, it being insufficient to do the whole work.

An appropriation of $50,000 was made by the act approved June 18, 1878, for the continuation of the improvement, $20,000 to be applied to the Washington Harbor and Channel and $30,000 to be applied to the Georgetown Channel. A channel 200 feet wide and 12 feet deep will be dredged along the Washington wharf-front, and one 16 feet deep and 200 feet wide through the bar in the Georgetown Channel above the Long Bridge.

The subject of a permanent improvement was referred by Congress to a board of survey appointed March 5, 1872, and whose report was printed during the third session of the Forty-second Congress (Mis. Doc. No. 15). The plan of the board provided for a wide and deep channel along the Virginia channel of the river, the material excavated therefrom to be deposited on the flats, the construction of bulkheads along the new front, and the correction of the curvature of the river. The engineer in charge now submits a modified plan and estimate (see Appendix G 1 of this report), which embraces the most important features of the original design. He proposes to dredge channels 15 and 20 feet deep (as shown on the maps accompanying his report) on lines varying but slightly from those of the board, and to place the dredged material on the flats.

The estimated cost of the work he proposes is $2,592,000; and he suggests that $200,000 be appropriated each year, in order to insure a low contract-price and substantial progress in its completion.

An examination of the rocks near the outlet-lock of the Chesapeake and Ohio Canal, above Georgetown, was made in March, 1878, in compliance with a resolution of the House of Representatives. They are in one group, a part of which stands above low-water. The cost of removal to 9 feet depth at low-water will be $44,000.

July 1, 1877, amount available	$2,856 62	
Amount appropriated by act approved June 18, 1878	50,000 00	
		$52,856 62
July 1, 1878, amount expended during fiscal year		2,778 40
July 1, 1878, amount available		50,078 22

Amount (estimated) required for completion of the project submitted above	$2,592,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880	244,000 00

(See Appendix G 1.)

2. *Improvement of Accotink Creek, Virginia.*—This work, which was commenced in 1872, has since remained suspended, no appropriation for its completion having been made. The amount required to complete the channel between the town of Accotink and the bay is, according to the original estimate, $14,000.

(See Appendix G 2.)

3. *Improvement of Occoquan River, Virginia.*—The appropriation made by the act approved June 18, 1878, for the completion of this improvement, will be expended in dredging a channel through the bar at the mouth of the river where it enters Occoquan Bay, and should the funds permit, in dredging at other points where the channel has deteriorated. The depth of channel proposed is 5 feet, which is the ruling depth in the bay. No work was done during the last fiscal year for want of funds.

July 1, 1877, amount available	$202 01	
Amount appropriated by act approved June 18, 1878	10,000 00	
		$10,202 01
July 1, 1878, amount expended during fiscal year		202 01
July 1, 1878, amount available		10,000 00

(See Appendix G 3.)

4. *Improvement of Aquia Creek, Virginia.*—This work will be completed with the appropriation of $5,000 made June 18, 1878. But as this is only one-third of the estimate, the dimensions of the channel will be correspondingly reduced. A channel 5 feet deep at low-water will be dredged above and below the railroad bridge, where the depth is insufficient, and the material deposited on the sides of the cut.

Amount appropriated by act approved June 18, 1878	$5,000 00
July 1, 1878, amount available	5,000 00

(See Appendix G 4.)

5. *Improvement of Nomoni Creek, Virginia.*—A material increase of trade and additional facilities for transportation have resulted from the improvement effected at the mouth of this creek. The work has, however, remained suspended during the year, owing to the lack of funds.

The action of winds and currents, together with constant passage of steamers through the cut, has caused the material to wash from the slopes, and it is important that the channel should be widened and deepened at several points in order that the work may be satisfactorily completed. For this purpose an appropriation of $10,000 is recommended by the engineer in charge.

Amount (estimated) required for completion of existing project	$10,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880	10,000 00

(See Appendix G 5.)

6. *Improvement of Rappahannock River, Virginia.*—At the date of the last annual report dredging was in progress at Fredericksburg, under the appropriation of $10,000 made August 14, 1876. This work was continued until July 26, 1877, when the available funds were exhausted.

The act of June 18, 1878, appropriates $13,500 for the continuation of the improvement. This sum will be expended in the construction of dikes along the river near Fredericksburg, for the purpose of contract-

ing the width and providing a place of deposit for the sand which it is proposed to dredge from the channel.

It is probable that the work already executed at Fredericksburg Bar, together with that proposed during the present season, will insure permanent results at this point. The engineer in charge, therefore, recommends that the improvement of the river between Fredericksburg and Tappahannock be resumed in accordance with the original plan.

The estimated cost of a channel 100 feet wide and 10 feet deep at low water, through the bars and shoals between those points, is $50,000, of which $30,000 could be profitably expended the next fiscal year.

July 1, 1877, amount available (not including $631.62 due on contracts)	$2,287 39	
Amount appropriated by act approved June 18, 1878	13,500 00	
		$15,787 39
July 1, 1878, amount expended during fiscal year (not including $631.62 due on contracts)		2,287 39
July 1, 1878, amount available		13,500 00
Amount (estimated) required for completion of existing project		50,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880		30,000 00

(See Appendix G 6.)

7. *Improvement of Leonardtown Harbor, Maryland.*—A survey of this harbor was made in 1874, and a report, with estimates of cost of improvement, will be found in the Report of the Chief of Engineers for 1875, part 2, page 108. The improvement proposed is the excavation of a channel, 150 feet wide and 9 feet deep, from the 9-foot curve in Breton Bay to the wharf at Leonardtown. The sum of $5,000, appropriated June 18, 1878, will be applied to the commencement of the work during the present season. For its completion $25,000 will be needed, and the engineer in charge recommends an appropriation of $15,000 for the next fiscal year.

Amount appropriated by act approved June 18, 1878	$5,000 00
July 1, 1878, amount available	5,000 00
Amount (estimated) required for completion of existing project	25,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880	15,000 00

(See Appendix G 7.)

8. *Improvement of Hampton River, Virginia.*—The obstruction to the navigation of Hampton River is a bar at its mouth. A survey of this bar was made in 1874, and a report, with estimates of the cost, will be found in the Report of the Chief of Engineers for 1875, part 2, page 152.

The act of June 18, 1878, appropriated $10,000 for this work, which will be expended in dredging a channel 8 to 9 feet deep and of such width as the funds allow through the bar.

The sum of $6,000 will be required for the completion of the work according to the original estimate.

Amount appropriated by act approved June 18, 1878	$10,000 00
July 1, 1878, amount available	10,000 00
Amount (estimated) required for completion of existing project	6,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880	6,000 00

(See Appendix G 8.)

9. *Improvement of Elizabeth River, Virginia.*—During the past year a cut-off has been dredged near the lock of the Albemarle and Chesapeake Canal in order to counteract the effect of tidal currents at a sharp bend in the river at that point. The work has been attended with successful results, greatly increasing the safety of navigation. The "Gap," a short

distance below, has also been widened so as to facilitate the passage of steamers and long tows.

An appropriation of $5,000 was made June 18, 1878, for this work, which was required to complete the deepening of the approaches to the "Gap" and to remove small bars which cause some obstruction below this point.

July 1, 1877, amount available	$4,989 89	
Amount appropriated by act approved June 18, 1878	5,000 00	
		$9,989 89
July 1, 1878, amount expended during fiscal year		4,721 94
July 1, 1878, amount available		5,267 95

(See Appendix G 9.)

10. *Improvement of Norfolk Harbor, Virginia.*—This improvement was commenced in October, 1877, under the appropriation of $35,000 made by the river and harbor act of August 14, 1876. A channel from 20 to 22 feet deep at low water with an average width of 530 feet has been dredged through the bar at the mouth of the eastern branch of Elizabeth River in the immediate harbor. The material found was a very soft blue mud, which was deposited on Craney Island Flats, 6¼ miles from Norfolk.

Dredging was suspended in April, 1878, and some additional dredging along the Berkeley Flats will be required to complete this channel.

The United States Advisory Board to the Harbor Commissioners of Norfolk submitted in May, 1878, a plan for the general improvement of the harbor and approaches so as to secure 25 feet of water from Hampton Roads to the navy-yard.

An estimate of the cost of this work, the total amount of which is $317,955, was prepared by the engineer in charge, and, together with the report of the United States advisory board, will be found in detail in the appendix to this report.

July 1, 1877, amount available	$34,710 85	
Amount appropriated by act approved June 18, 1878	50,000 00	
		$84,710 85
July 1, 1878, amount expended during fiscal year		31,405 07
July 1, 1878, amount available		53,305 78
Amount (estimated) required for completion of existing project		293,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880		100,000 00

(See Appendix G 10.)

11. *Improvement of Chickahominy River, Virginia.*—The improvement of the navigation of this river was provided for by an appropriation of $5,000 in the river and harbor act of June 18, 1878, which it is proposed to expend in dredging channels through Binn's Bar and Windsor Shades Bar, which are the principal obstructions, and which are near the head of navigation.

An examination of this river was made in accordance with the act of June 23, 1874, the report of which will be found in the Report of the Chief of Engineers for 1875, part 2, page 170.

Amount appropriated by act approved June 18, 1878	$5,000 00
July 1, 1878, amount available	5,000 00
Amount (estimated) required for completion of existing project	5,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880	5,000 00

(See Appendix G 11.)

12. *Improvement of Blackwater River, Virginia.*—A survey of this river was made in 1874, and a report upon the same with an estimate of

the cost of improvement will be found in the Report of the Chief of Engineers for 1875, part 2, page 161. The sum of $5,000 was appropriated for the improvement by the river and harbor act of June 18, 1878. The work proposed during the present season is the removal of snags, logs, and similar obstructions to navigation.

For the completion of the improvement $10,000 will be required.

Amount appropriated by act approved June 18, 1878	$5,000 00
July 1, 1878, amount available	5,000 00
Amount (estimated) required for completion of existing project	10,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880	10,000 00

(See Appendix G 12.)

13. *Improvement of French Broad River, North Carolina.*—The survey of this river was completed in September, 1877, and estimates of the cost of different methods of improvement will be found detailed in Appendix G 13 of this report. The least expensive of the plans proposed is that of securing 2½ feet of water by means of wing-dams and the excavation of gravel and rock at the shoals, the estimated cost being $45,500.

The removal of snags was commenced in October, 1877, and, after suspension of work during the winter months, was again resumed in the spring, and is now nearly completed. Some rock for wing-dams has also been quarried.

The appropriation of $15,000 of June 18, 1878, for the continuation of the improvement will be expended in building wing-dams and in the removal of rock and gravel bars which obstruct the channel. For the completion of the work $30,000 will be required, of which the engineer in charge recommends that $20,000 be appropriated for the fiscal year ending June 30, 1880.

July 1, 1877, amount available	$10,000 00	
Amount appropriated by act approved June 18, 1878	15,000 00	
		$25,000 00
July 1, 1878, amount expended during fiscal year		7,162 08
July 1, 1878, amount available		17,837 92
Amount (estimated) required for completion of existing project		30,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880		20,000 00

(See Appendix G 13.)

14. *Improvement of Perquimans River, North Carolina.*—The work of removing the stumps which obstructed the navigation of the river near the town of Hertford was continued until October, 1877. A channel 200 feet wide and 8½ feet deep was secured, so that steamers now pass through the river without detention. The stumps were of cypress, firmly imbedded, with large and extended roots. The diameter varied from 1 to 7 feet, with an average depth of water over them of 6 feet. They were first blasted with giant-powder, and the pieces afterward removed by snag-hooks and derrick, with the aid of a diver.

July 1, 1877, amount available	$2,154 14
July 1, 1878, amount expended during fiscal year	1,566 90
July 1, 1878, amount available	587 24

(See Appendix G 14.)

15. *Improvement of Roanoke River, North Carolina.*—Work has remained suspended for want of funds, no appropriation having been made since June 23, 1874.

The estimated cost of removing snags from the river, and repairing the dike at Indian Highland Bar, is $5,000.

July 1, 1877, amount available	$181 98
July 1, 1878, amount expended during fiscal year	181 98
Amount (estimated) required for completion of existing project	222,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.	5,000 00

(See Appendix G 15.)

16. *Improvement of Pamplico River, North Carolina.*—The pile obstructions near Hill's Point, 6 miles below Washington, have been removed and a channel 175 feet wide and 9 feet deep at low-water has also been dredged over the bar near the town.

A survey of a shoal portion of the river, about 1 mile below, showed that the deepening of the channel at this point would be of advantage to navigation, but on commencing the work it was found that under the layer of material of which the bed of the river appeared to be composed there were large numbers of stumps, which were only removed with great difficulty and by the aid of giant-powder. A 70-feet channel was, however, completed through these stumps in June.

For widening this channel the balance of the original estimate, $10,000, will be required.

July 1, 1877, amount available		$14,636 04
July 1, 1878, amount expended during fiscal year		12,565 47
July 1, 1878, amount available		2,070 57
Amount (estimated) required for completion of existing project		10,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		10,000 00

(See Appendix G 16.)

17. *Improvement of Nansemond River, Virginia.*—The channel through Suffolk Bar has been widened from 60 to 80 feet, with a depth of 8 feet at low-water. A channel 80 feet wide and 8 feet deep was also dredged through Shingle Creek Bar, a short distance below, which somewhat obstructed navigation at low-water. The dike at Western Branch Bar has been partially repaired and the channel at this point remains in good condition.

The sum of $2,000 was appropriated for the completion of this work by the act of June 18, 1878, and no further expenditure will be required.

July 1, 1877, amount available	$4,740 52	
Amount appropriated by act approved June 18, 1878	2,000 00	
		$6,740 52
July 1, 1878, amount expended during fiscal year		4,639 79
July 1, 1878, amount available		2,100 73

(See Appendix G 17.)

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

To comply with provisions of the river and harbor act of June 18, 1878, Mr. Abert has been charged with and is now engaged upon examinations and surveys at the following localities, the results of which will be duly submitted when received:

1. *The Yadkin, North Carolina, between the bridge on the North Carolina Railroad and Wilkesborough.*
2. *Dan River, Virginia, from Clarksville, via Danville, Virginia, to Danbury, North Carolina.*
3. *Staunton River, from Roanoke Depot, in Charlotte County, Virginia, to Brookneal, in the county of Campbell, Virginia.*

SURVEY FOR AN INTERIOR WATER COMMUNICATION BETWEEN NORFOLK, VIRGINIA, AND THE ATLANTIC SOUTH OF HATTERAS.

In the second section of the river and harbor act of June 18, 1878, there is made an appropriation of $20,000 "for the purpose of having a complete survey and examination of all the water lines and routes leading from the harbor of Norfolk to the Atlantic Ocean south of Hatteras, including any communication that may be practicable with the Cape Fear River." This survey has been assigned to Capt. C. B. Phillips, Corps of Engineers, and is in progress.

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

To comply with provisions of the river and harbor act of June 18, 1878, Captain Phillips has been charged with and is now engaged upon examinations and surveys at the following localities, the results of which will be duly submitted when received:

1. *North Landing River, Virginia.*
2. *Onancock Harbor, Virginia.*
3. *The Nottoway River, Virginia.*
4. *Peedee River, from Cheraw, South Carolina, to the mouth of Uwharie River, North Carolina.*
5. *The Trent River, North Carolina.*
6. *Neuse River, from Smithfield to Goldsborough, North Carolina.*
7. *Chowan River, North Carolina.*
8. *The Tar River, North Carolina, from Washington to Tarborough.*

IMPROVEMENT OF THE RIVERS AND HARBORS ON THE COAST OF SOUTH CAROLINA, GEORGIA, AND THE ATLANTIC COAST OF FLORIDA.

Officer in charge, Lieut. Col. Q. A. Gillmore, Corps of Engineers, having under his immediate orders Capt. James C. Post, Corps of Engineers.

1. *Improvement of the harbor of Charleston, South Carolina.*—Very little work was carried on at this harbor during the fiscal year. The outer end of Bowman Jetty, for an additional length of 30 feet, was lowered to a level of 2 feet above mean low-water by the removal of 200 cubic yards of stone. The stone was thrown into the work on either side. Some little dredging was done in Beach Channel by the United States dredging-steamer Henry Bender, but it was soon suspended on account of the great expense attending it. A survey of the channel was made, which showed that the shortening of the jetty had not been attended with any widening of the channel at that point, but that the western end of Drunken Dick Shoal moved toward Sullivan's Island as the jetty was shortened. The channel has been straightened as a direct result of the work, and was, on the whole, rather better than ever before. It had not been deepened, but, on the contrary, was somewhat shoaler than it was four or five years ago.

Several borings made upon and in the vicinity of the northern end of the Charleston Bar, with the object of ascertaining the fitness of the material composing the bar for supporting permanent works of improvement, indicated that works of moderate weight could safely be built upon it. On the 9th of March, 1878, a project was submitted by Lieutenant-Colonel Gillmore for the permanent improvement of the channel of entrance into Charleston Harbor, by means of low jetties, one springing from Morris and the other from Sullivan's Island, and occupying curved

lines so located that their sea ends, on the bar, would be nearly parallel to each other, one-half to five-eighths of a mile apart.

The works are designed to be of riprap stone resting on a mattress of fascines.

For jetties with a half a mile gap between them the estimated cost was placed at $1,800,000. In the annual report of the engineer in charge it is stated that some reduction can be made in the estimates.

During the present fiscal year it is the intention to begin the construction of these jetties, the sum of $200,000 having been appropriated for that purpose by act of June 18, 1878.

Most of this sum will be expended in constructing and laying an apron, composed of fascine mattresses, or of a combination of timber, brush, and fascines, to serve as the foundation of the shore end of the North jetty. It will be laid of the full width, and will be loaded with a layer of stone about 2½ feet in depth to keep it secure.

July 1, 1877, amount available	$7,368 71	
Amount appropriated by act approved June 18, 1878	200,000 00	
		$207,368 71
July 1, 1878, amount expended during fiscal year	6,392 36	
July 1, 1878, outstanding liabilities	1,000 00	
		7,392 36
July 1, 1878, amount available		199,976 35
Amount (estimated) required for completion of existing project		1,600,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		500,000 00

(See Appendix H 1.)

2. *Improvement of Savannah River and Harbor, Georgia.*—During the fiscal year just closed work was restricted mainly to dredging in these localities, viz: (1) on the shoal northeast of Fort Pulaski; (2) on the shoal southwest of Oyster Bed light near Fort Pulaski, and (3) in the new channel at "The Wrecks." The work of carefully gauging the stream at several points, with a view to project for future work, was begun.

During the present fiscal year the gauging of the river will be finished, probably in July, and the submerged dam at the Cross Tides, consisting of a superstructure of riprap stone resting upon a mattress of fascines, or upon a foundation of timber and brush, or timber, brush, and fascines, will be constructed. When this has been carried up to the height deemed requisite, and the effects of the increased ebb flow in front river have been observed and studied, a project for subsequent work will be determined.

July 1, 1877, amount available	$37,137 32	
Amount appropriated by act approved June 18, 1878	70,000 00	
		$107,137 32
July 1, 1878, amount expended during fiscal year	36,453 83	
July 1, 1878, outstanding liabilities	242 19	
		36,696 02
July 1, 1878, amount available		70,441 30
Amount (estimated) required for completion of existing project		229.320 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		150,000 00

(See Appendix H 2.)

3. *Improvement of Saint Augustine Creek (Thunderbolt River), Georgia.*—This river constitutes part of the inside passage between the Savannah River and Wassaw Sound, and is used by small freight and passenger steamers plying between Savannah and Brunswick, Darien, Fernandina, and the Saint John's *River.*

The only improvement that is recommended is the removal of a single dangerous obstruction, consisting of a large timber dry-dock, sunk there during the civil war, which lies directly in the channel.

No appropriation was ever made by Congress for the improvement of this stream.

Appropriation recommended for this purpose $5,000 00

(See Appendix H 3.)

4. *Improvement of the Harbor of Darien, Georgia.*—The first appropriation for this purpose, amounting to $8,000, was made by act approved June 18, 1878. It will be expended in removing a shoal in Back River, between Commodore and Wolf Islands, Back River being one of the outlets into Doboy Sound of the Darien River.

No additional appropriation is required.

(See Appendix H 4.)

5. *Improvement of inside passage between the Saint John's River and Fernandina, Florida.*—No work on this passage was done during the fiscal year just closed for want of funds, and no appropriation was made for the present fiscal year. The engineer in charge reports that no material changes in the channel have taken place since the date of his last annual report, and no changes are anticipated so long as the passage is used by steamboats. There are two points where the passage is very contracted.

At one of them, known as Gunnison's Cut, the width is scarcely 30 feet, and the low-water depth does not exceed 2½ feet. The enlargement of the channel at these points is recommended so long as the bar at the mouth of Saint John's River remains unimproved.

An appropriation of $10,000 is needed, to be expended upon the inside passage or at the mouth of the Saint John's River, as the Secretary of War shall direct.

(See Appendix H 5.)

6. *Improvement of the bar at the mouth of Saint John's River, Florida.*—No work has been done on this bar for several years, no appropriation for its improvement having been made. It is proposed by the engineer in charge to expend a portion of the $10,000 appropriated by act approved June 18, 1878, in gauging the stream at several points near its lower end, and in making a series of borings upon the bar at its mouth, with a view to obtaining the necessary data for a project for its permanent improvement.

(See Appendix H 6.)

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

To comply with provisions of the river and harbor act of June 18, 1878, Lieutenant-Colonel Gillmore has been charged with and is now engaged upon examinations and surveys at the following localities, the results of which will be duly submitted when received:

1. *The Savannah River above Augusta, Georgia.*
2. *The peninsula of Florida with a view to the construction of a ship-canal from the Saint Mary's River to the Gulf of Mexico.*
3. *The mouth of Saint John's River, Florida.*
4. *For survey of the Saint John's River, Florida, between Lake George and Lake Monroe, and estimates of cost of deepening Volusia Bar and straightening the river by cut-offs.*

GULF OF MEXICO.

IMPROVEMENT OF THE HARBORS OF MOBILE, ALABAMA, AND OF PENSACOLA AND CEDAR KEYS, FLORIDA—IMPROVEMENT OF THE NAVIGATION OF RIVERS IN ALABAMA AND FLORIDA, AND OF CHATTAHOOCHEE AND FLINT RIVERS, GEORGIA.

Officer in charge, Capt. A. N. Damrell, Corps of Engineers.

1. *Improvement of harbor at Mobile, Alabama.*—With the exception of the removal of some logs from the channel no work was carried on in prosecution of this improvement during the fiscal year 1877–'78.

Under an appropriation of $10,000 by act of Congress approved June 18, 1878, it is proposed to make tests, surveys, and borings to determine the feasibility of obtaining a ship-channel of 22 feet from the lower anchorage in Mobile Bay to the wharves of the city of Mobile.

No appropriation will be required for fiscal year ending June 30, 1880.

July 1, 1877, amount available	$4,015 57	
Amount appropriated by act approved June 18, 1878	10,000 00	
		$14,015 57
July 1, 1878, amount expended during fiscal year		2,146 31
July 1, 1878, amount available		11,869 26

(See Appendix I 1.)

2. *Improvement of harbor at Pensacola, Florida.*—Under appropriation of $20,000 made June 18, 1878, it is proposed to remove the wrecks in this harbor, and make such other improvements as the appropriation allows.

No appropriation will be required for the fiscal year ending June 30, 1880.

Amount appropriated by act approved June 18, 1878	$20,000 00
July 1, 1878, amount available	20,000 00

(See Appendix I 2.)

3. *Improvement of harbor at Cedar Keys, Florida.*—During the fiscal year 14,221 cubic yards of material were excavated from the shoal between Depot Key and Way Key, giving a channel through the Middle Ground 80 feet wide and 11½ feet deep at mean low tide.

It is proposed during the fiscal year 1878–'79 to continue the improvement, by dredging, under the appropriation of $20,000 of June 18, 1878.

An appropriation of $50,000 is recommended by the officer in charge for fiscal year ending June 30, 1880.

July 1, 1877, amount available	$9,983 65	
Amount appropriated by act approved June 18, 1878	20,000 00	
		$29,983 65
July 1, 1878, amount expended during fiscal year		9,983 65
July 1, 1878, amount available		20,000 00
Amount (estimated) required for completion of existing project		81,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880		50,000 00

(See Appendix I 3.)

4. *Improvement of Choctawhatchee River, Alabama and Florida.*—Work on the improvement of this river was carried on during the months of July and August, 1877, when the balance of the appropriation made by act of Congress approved August 14, 1876, being exhausted, operations were discontinued *after the removal of more than 630* snags and 1,200

overhanging trees and deepening of shoal at Millers Field by the removal of drift and gravel.

Appropriation recommended by the officer in charge for fiscal year ending June 30, 1880, for continuing the improvement is $19,000.

July 1, 1877, amount available		$2,786 38
July 1, 1878, amount expended during fiscal year		2,577 81
July 1, 1878, amount available		208 57
Amount (estimated) required for completion of existing project		19,332 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		19,000 00

(See Appendix I 4.)

5. *Improvement of Apalachicola River, Florida.*—Work was prosecuted on this river from January, 1878, to the middle of April, 1878, at Moccasin Slough and other points, and consisted in the construction of a dam 130 feet long, the removal of 486 cubic yards of earth and 270 logs and snags, and many overhanging trees.

It is intended during next year to continue the improvement with the appropriation of $8,000 of June 18, 1878, by removal of sunken logs, snags, and overhanging trees, improvement of cut-off, and widening and straightening channel through Moccasin Slough.

Appropriation recommended by the officer in charge for fiscal year ending June 30, 1880, $20,000.

July 1, 1877, amount available	$4,776 91	
Amount appropriated by act approved June 18, 1878	8,000 00	
		$12,776 91
July 1, 1878, amount expended during fiscal year		4,074 33
July 1, 1878, amount available		8,702 58
Amount (estimated) required for completion of existing project		52,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		20,000 00

(See Appendix I 5.)

6. *Improvement of Chattahoochee and Flint Rivers, Georgia.*—This work was continued during the year as follows:

On Chattahoochee River, completion of 4-feet channel over Wolfax Bar, by construction of shore protection, jetties, and wing-dams. The following bars were also improved by the removal of snags, logs, &c.: Abercrombie, Shell Creek, Chimney's Bluff, and Snake Shoal. A channel 60 feet in width and 4 feet depth was obtained by blasting rock on Uchee, Slick Bluff, and Hardridges Shoals. On Flint River, by blasting rock and removing sunken logs, a channel 60 feet wide and 4 feet deep was cleared between the wharf at Bainbridge and Lamberts Island.

It is proposed during next year to continue the improvement of Chattahoochee by clearing the channel at the most dangerous shoals, such as Hardridges Shoals and Kings Rock, and the improvement of Flint River by removal of rocks, sunken logs, &c., between Lamberts Island and its mouth.

Appropriation recommended by the officer in charge for fiscal year ending June 30, 1880, for continuing the improvement, $50,000.

July 1, 1877, amount available	$25,565 09	
Amount appropriated by act approved June 18, 1878	28,000 00	
		$53,565 09
July 1, 1878, amount expended during fiscal year		21,647 57
July 1, 1878, amount available		31,917 52
Amount (estimated) required for completion of existing project		232,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		50,000 00

(See Appendix I 6.)

7. *Improvement of Black Warrior and Tombigbee Rivers, Alabama.*—During the year the Warrior River was cleared of logs, snags, and overhanging trees from the mouth of the river to Log Shoals. There is now a channel of 2½ feet minimum depth from the mouth of the river to Eastport, a distance of 62 miles.

It is proposed during next year to improve Warrior River from Eastport to Tuscaloosa, and the Tombigbee from Demopolis to its mouth.

Appropriation recommended by the officer in charge for fiscal year ending June 30, 1880, $100,000.

July 1, 1877, amount available	$5,463 04	
Amount appropriated by act approved June 18, 1878	40,000 00	
		$45,463 04
July 1, 1878, amount expended during fiscal year		4,318 24
July 1, 1878, amount available		41,144 80
Amount (estimated) required for completion of existing project		104,603 00
Amount that can be profitably expended in fiscal year ending June 30, 1880		100,000 00

(See Appendix I 7.)

8. *Improvement of Tombigbee River above Columbus.*—With the appropriation of $12,000 of June 18, 1878, it is proposed to improve the navigation of this river by the removal of all snags, sunken logs, and overhanging trees, and the improvement of the worst bars in the river above Columbus.

Appropriation recommended by officer in charge for fiscal year ending June 30, 1880, for continuing the improvement, $18,000.

(See Appendix I 8.)

9. *Improvement of Alabama River.*—With the appropriation of June 18, 1878, it is proposed during next year to close cut-off about 12 miles above the mouth of the river, by construction of dams and jetties, and clear the river of logs, snags, and overhanging trees from Wetumpka to its mouth.

Appropriation recommended by the officer in charge for fiscal year ending June 30, 1880, for the continuation of this improvement is $100,000.

Amount appropriated by act approved June 18, 1878	$25,000 00
July 1, 1878, amount available	25,000 00
Amount (estimated) required for completion of existing project	229,741 00
Amount that can be profitably expended in fiscal year ending June 30, 1880	100,000 00

(See Appendix I 9.)

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

To comply with provisions of the river and harbor act of June 18, 1878, Captain Damrell has been charged with and is now engaged upon examinations and surveys at the following localities, the results of which will be duly submitted when received:

1. *The Conecuh River, Alabama.*
2. *The Patsaligo River, Alabama.*
3. *The Escambia River, Alabama.*
4. *The Chickasahoy River, Mississippi.*
5. *The Pascagoula River, Mississippi.*
6. *The Suwannee River, Florida.*
7. *The Caloosahatchie River, Florida.*
8. *The mouth of Hillsborough River, Florida.*
9. *Tampa Bay, Florida.*
10. *The Flint River, Georgia, from Albany to Montezuma.*
11. *Apalachicola Bay, Florida.*

IMPROVEMENT OF THE MOUTH OF MISSISSIPPI RIVER AT SOUTHWEST PASS; OF THE ENTRANCE TO GALVESTON HARBOR, AND THE SHIP-CHANNEL IN GALVESTON BAY; OF SABINE PASS AND PASS CAVALLO, AND OF SABINE, NECHES, AND TRINITY RIVERS, TEXAS, AND BAYOU LAFOURCHE, LOUISIANA—IMPROVEMENT OF THE HARBOR AT NEW ORLEANS.

Officer in charge, Capt. C. W. Howell, Corps of Engineers, with Capt. C. E. L. B. Davis, Corps of Engineers, under his immediate orders.

1. *Improvement of the mouth of the Mississippi River at Southwest Pass.*—The act of Congress approved August 14, 1876, provided that the appropriation for this work should not be available whenever there should be a channel of 18 feet in depth through South Pass.

This depth through South Pass having been reported, dredging at Southwest Pass was suspended August 22, 1877.

One of the idle dredge-boats, the *Essayons*, formerly employed upon this work, was sent to Sabine Pass, Texas, to perform the work at that place provided for by Congress.

The *Essayons* becoming disabled, her mate, the *McAlester*, was sent to relieve her, but was lost on the voyage from New Orleans to Sabine Pass, the particulars of which, so far as known, are given by Captain Howell in Appendix J 1 of this report.

The *Essayons* and the other property belonging to the work (except the end dock coal barge and storehouse, which were sold at auction, and the steam-launch, which was transferred to the work for improving harbor at Galveston, Texas) have been transferred to the work for improvement of Sabine Pass.

July 1, 1877, amount available	$10,760 98	
August 6, 1877, amount allotted from appropriation for repair, preservation, extension, and completion of river and harbor works	12,200 00	
		$22,960 98
July 1, 1878, amount expended during fiscal year		22,960 98

(See Appendix J 1.)

2. *Improvement of the entrance to Galveston Harbor, Texas.*—This work was suspended November 30, 1877, on account of exhaustion of the appropriation.

The changes produced on the inner bar by the work are very gratifying; the survey of June, 1877, showing a least depth over the bar of 20 feet, with a least width between the 20-feet curves of 200 feet, where before the work commenced there existed a narrow and intricate channel of but 12 feet in depth.

Work on the outer bar had not progressed far enough at the time of suspension to produce important results.

With the large number of gabions on hand ready to sink in the Bolivar gabionnade, it is thought by the officer in charge that results will be obtained sufficient to show that the completion of the work will probably secure a depth over the outer bar equal at least to that already secured through the agency of the gabionnade over the inner bar.

Original estimate	$1,259,456 43
Revised estimate	559,740 00
Whole amount appropriated	477,000 00
Whole amount expended	357,662 72

July 1, 1877, amount available	$36,052 60	
Amount appropriated by act approved June 18, 1878	50,000 00	
Amount appropriated by act approved June 7, 1878	75,000 00	
		$161,052 60

July 1, 1878, amount expended during fiscal year	$37,089 60	
July 1, 1878, outstanding liabilities	4,625 72	
		$41,715 32
July 1, 1878, amount available		119,337 28
Amount (estimated) required for completion of existing project		82,740 00
Amount that can be profitably expended in fiscal year ending June 30, 1880*		150,000.00

(See Appendix J 2.)

3. *Improvement of ship-channel in Galveston Bay, Texas, between Bolivar Channel and Red Fish Bar.*—Expenditure of the appropriation of 1876 for this work having been suspended, upon recommendation approved by the honorable Secretary of War, to await further action of Congress, no work was performed during the past fiscal year.

During the present fiscal year it is proposed to expend the money now available in excavating, by contract, a channel 12 feet deep at mean low tide, and 100 feet wide at bottom, from the head of Bolivar Channel to the United States cut through Red Fish Bar.

July 1, 1877, amount available	$72,000 00	
Amount appropriated by act approved June 18, 1878	75,000 00	
		$147,000 00
July 1, 1878, amount available		147,000 00
Amount (estimated) required for completion of existing project, 12 feet deep and 100 feet wide		446,326 42
Amount that can be profitably expended in fiscal year ending June 30, 1880.		200,000 00

(See Appendix J 3.)

4. *Improvement of Sabine Pass, Texas.*—In consequence of suspension of dredging at Southwest Pass of the Mississippi River the United States dredge-boats Essayons and McAlester were idle at the time bids received for the performance of this work by contract were being considered.

With a view to economy for the government and advantage to the work the bids were rejected and the *Essayons* sent to do the work.

The disablement of the *Essayons* and the loss of the *McAlester*, together with unavoidable delay experienced in making repairs to the *Essayons* retarded the progress of the work.

Upon completion of repairs to the *Essayons* she will be returned to Sabine Pass to resume the work of dredging.

The officer in charge submits an estimate of $100,000 for the continuation of this improvement for the fiscal year ending June 30, 1880, but owing to want of sufficient information in this office as to the necessity for so large an appropriation this estimate is reduced to $30,000, the amount of last year's appropriation.

July 1, 1877, amount available	$50,489 42	
Amount appropriated by act approved June 18, 1878	30,000 00	
		$80,489 42
July 1, 1878, amount expended during fiscal year	35,252 02	
July 1, 1878, outstanding liabilities	2,385 20	
		37,637 22
July 1, 1878, amount available		42,852 20
Amount (estimated) required for completion of existing project 20-feet channel		302,317 00
Amount that can be profitably expended in fiscal year ending June 30, 1880, as revised in this office		30,000 00

(See Appendix J 4.)

*NOTE.—The amount required for next fiscal year in excess of balance remaining after deducting total amount *appropriated from amount estimated* for completion of existing project *is necessary to cover loss to the work sustained* by frequent suspensions *due to inadequate appropriations.*

5. *Improvement of the narrows above Orange, on the Sabine River, Texas, and deepening the channel at the mouth of said river.*—There was appropriated for this work at the last session of Congress $10,000, with which it is proposed to dredge a channel at the mouth of the river 5 feet deep at mean low tide and 100 feet wide, or so much thereof as the appropriation will permit.

Amount appropriated by act approved June 18, 1878	$10,000 00
July 1, 1878, amount available	10,000 00
Amount (estimated) required for completion of existing project	21,033 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.	21,033 00

(See Appendix J 5.)

6. *Deepening the channel at the mouth of the Neches River, Texas, and removing obstructions to Beaumont.*—With the $8,000 available for this work it is proposed to excavate a channel 5 feet deep at mean low tide and 40 feet wide, or so much thereof as the amount will permit, through the bar at the mouth of the river.

Original estimate—work at mouth	$26,318 05
Amount appropriated by act approved June 18, 1878	8,000 00
July 1, 1878, amount available	8,000 00
Amount (estimated) required for completion of existing project	18,318 05
Amount that can be profitably expended in fiscal year ending June 30, 1880.	18,318 05

(See Appendix J 6.)

7. *Deepening the channel at the mouth of the Trinity River, Texas, and removing obstructions to Liberty.*—The $10,000 made available by the last Congress will be expended in dredging a channel 5 feet deep and 100 feet wide across the bar obstructing the entrance to the river, or so much thereof as the amount will permit.

Original estimate—work at mouth	$40,000 00
Removing snags, &c	6,000 00
Amount appropriated by act approved June 18, 1878	10,000 00
July 1, 1878, amount available	10,000 00
Amount (estimated) required for completion of existing project	7,967 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.	7,967 00

(See Appendix J 7.)

8. *Improvement of Pass Cavallo, inlet into Matagorda Bay, Texas.*—The river and harbor act of August 14, 1876, appropriated $20,000 for this work.

As that amount was manifestly too small for the commencement of a work of this nature, it was recommended, and the recommendation was approved by the honorable Secretary of War, that the work be held to await further action of Congress.

Great changes have been reported in the pass since the last survey, to ascertain the nature of which an examination will be made, and upon its completion the officer in charge will submit a project for expenditure of the appropriations now available.

Original estimate		$715,325 00
Whole amount appropriated		45,000 00
July 1, 1877, amount available	$20,000 00	
Amount appropriated by act approved June 18, 1878	25,000 00	
		45,000 00
July 1, 1878, amount available		45,000 00
Amount (estimated) required for completion of existing project		670,325 00
Amount that can be profitably expended in fiscal year ending June 30, 1880, as revised in this office		130,000 00

(See Appendix J 8.)

9. *Removing obstructions in Bayou Lafourche, Louisiana.*—The amount available for this work during the present fiscal year will be applied to

the removal of stumps and snags between Thibodeauxville and Parr's Canal.

Amount appropriated by act approved June 18, 1878	$10,000
July 1, 1878, amount available	10,000

(See Appendix J 9.)

10. *Improvement of the harbor at New Orleans, Louisiana.*—The amount available for this work will be expended during the present fiscal year in protecting the river front of New Orleans, according to the plan adopted by the Commission of Engineers convened for that purpose, a report of which will be found in Appendix J 10 of this report.

Original estimate	$476,000 00
Whole amount appropriated	50,000 00
Amount appropriated by act approved June 18, 1878	50,000 00
July 1, 1878, amount available	50,000 00
Amount (estimated) required for completion of existing project	426,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.	200,000 00

(See Appendix J 10.)

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

To comply with provisions of the river and harbor act of June 18, 1878, Captain Howell has been charged with and is now engaged upon examinations and surveys at the following localities, the results of which will be duly submitted when received:

1. *Pearl River, Mississippi.*
2. *Brazos River in Texas from eight miles above its mouth down through its mouth to the outer edge of the bar in the Gulf of Mexico.*
3. *Aransas Pass and Bay up to Rockport and Corpus Christi, Texas, and Corpus Christi Pass and Channel.*
4. *The bar at the mouth of Brazos River, Texas, including a report upon the capacity of the harbor at the mouth of the Brazos, and its adaptability as a harbor of refuge and naval station.*
5. *Tangipahoa River, Louisiana.*

PROTECTION OF THE RIVER BANKS AT FORT BROWN, TEXAS, FROM ENCROACHMENTS OF THE RIO GRANDE.

Officer in charge, Capt. James F. Gregory, Corps of Engineers.

This work having sustained some injury at its up-stream end, the unexpended balance of the appropriation of July 31, 1876, was applied to continuing the work 130 feet up-stream from the point where the main structure had remained uninjured.

As the bank in front of the administration building has begun to wear away, it is apprehended that this building and much valuable land may be lost, and that the river may yet break through into the lagoon. To arrest this, since the work of protection has successfully withstood the high-water currents of last year and of this spring, the officer in charge recommends that the work be continued about 400 feet farther down stream, for the cost of which he submits an estimate of $14,400.

July 1, 1877, balance available of appropriation made by sundry civil act approved July 31, 1876	$2,802 41
July 1, 1878, amount expended during fiscal year	2,796 33
July 1, 1878, amount available	6 08
Amount that can be profitably expended in fiscal year ending June 30, 1880.	14,400 00

(See Appendix K.)

WESTERN RIVERS.

IMPROVEMENT OF OUACHITA AND YAZOO RIVERS—REMOVAL OF RED RIVER RAFT—IMPROVEMENT OF TONE'S AND CYPRESS BAYOUS AND OF THE MOUTH OF RED RIVER—PRESERVATION OF THE PORTS OF MEMPHIS AND VICKSBURG—WATER-GAUGES ON THE MISSISSIPPI AND ITS PRINCIPAL TRIBUTARIES.

Officer in charge, Capt. W. H. H. Benyaurd, Corps of Engineers.

1. *Improvement of Ouachita River, Arkansas and Louisiana.*—Low-water dams were constructed at Spoon Camp Shoals and Buffalo Flats, for the purpose of concentrating all the water, when at a low stage, in a single channel, and the snag-boat Wagner was employed in removing obstructions from the channel of the river.

During the coming season it is proposed, as far as the funds will allow, to build low-water dams at Hog-Eye Shoals, Slim Island, and Smack-Over Shoals, and to continue snagging operations with the *Wagner*.

July 1, 1877, amount available	$6,830 56	
Amount appropriated by act approved June 18, 1878	10,000 00	
		$16,830 56
July 1, 1878, amount expended during fiscal year		6,808 24
July 1, 1878, amount available		10,022 32
Amount that can be profitably expended in fiscal year ending June 30, 1880		25,000 00

(See Appendix L 1.)

2. *Improvement of Yazoo River, Mississippi.*—There being no snag-boat belonging to this work, and the funds appropriated not being sufficient to purchase one, the *Wagner* was taken from the Ouachita and employed in removing wrecks, snags, &c., from the channel of the river.

It is proposed during the coming season to operate in the same manner.

As there are many calls made for the *Wagner* (it being the only light-draught snag-boat in service) for work on the Southern rivers, and as it is impossible to do full justice to all, the officer in charge recommends that funds sufficient be appropriated to build another light-draught boat.

July 1, 1877, amount available	$13,956 51	
Amount appropriated by act approved June 18, 1878	25,000 00	
		$38,956 51
July 1, 1878, amount expended during fiscal year		13,799 68
July 1, 1878, amount available		25,156 83
Amount (estimated) required for completion of existing project		68,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880		50,000 00

(See Appendix L 2.)

3. *Removing raft in Red River and closing Tone's Bayou, Louisiana.*—*Removing raft in Red River.*—The steamer Florence was raised and employed during the season in removing obstructions from the channel and in keeping Red River open above Shreveport.

During the coming season it is proposed to continue these operations.

Closing Tone's Bayou.—A break having occurred at the east end of the dam, an allotment of $4,500 was made for its repair. With this amount, and with $3,000 furnished by the citizens of New Orleans, the break was repaired and the dam carried up to within 12 feet of high-water mark.

During the coming season it is proposed to carry the dam up to its full height and cover the top with a heavy layer of stone.

July 1, 1877, amount available	$2,262 32	
August 27, 1877, amount allotted for Tone's Bayou	4,500 00	
Amount appropriated by act approved February 7, 1878	6,000 00	
Amount appropriated by act approved June 18, 1878	24,000 00	
		$36,762 32
July 1, 1878, amount expended during fiscal year on raft-work	5,509 30	
July 1, 1878, amount expended during fiscal year on Tone's Bayou	4,807 08	
		10,316 38
July 1, 1878, amount available		26,445 94
Amount (estimated) required for completion of existing project for raft-work		130,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		50,000 00

(See Appendix L 3.)

4. *Improvement of Cypress Bayou, Texas.*—A new dredge was built last season to take the place of the old one, sunk in the bayou.

The new dredge will be employed this coming season in widening the three steamboat channels already dredged and in making a new channel through to the head of Fairy Lake.

July 1, 1877, amount available	$9,900 73	
Amount appropriated by act approved June 18, 1878	15,000 00	
		$24,900 73
July 1, 1878, amount expended during fiscal year		9,854 32
July 1, 1878, amount available		15,046 41
Amount (estimated) required for completion of existing project		20,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		20,000 00

(See Appendix L 4.)

5. *Removing snags and other obstructions from Red River, Louisiana.*—No work has heretofore been done upon the lower part of Red River. The appropriation of $25,000 of June 18, 1878, is the first that has been made.

It is proposed to expend that amount during the coming season in removing snags, wrecks, and other obstructions.

Amount appropriated by act approved June 18, 1878	$25,000 00
July 1, 1878, amount available	25,000 00
Amount (estimated) required for completion of existing project	150,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.	75,000 00

(See Appendix L 5.)

6. *Improvement of the mouth of Red River, Louisiana.*—The works designed for this improvement have for their object the opening of a navigable channel from Red River to the Mississippi, and from the Mississippi to the Atchafalaya. To this intent it is proposed to put a dam across Old River between the head of the Atchafalaya and the head of Turnbull's Island, and thus throw the volume of Red River into the Mississippi by way of Upper Old River; at the same time connection between the Atchafalaya and the Mississippi is maintained through Lower Old River.

Amount appropriated by act approved June 18, 1878	$150,000 00
July 1, 1878, amount available	150,000 00
Amount (estimated) required for completion of existing project	150,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.	150,000 00

(See Appendix L 6.)

7. *Improvement of the harbor and of Mississippi River at Memphis, Tennessee.*—This improvement has for its object the protection of the harbor

at Memphis. To that intent work will be commenced so soon as the stage of water will permit, and carried on to the extent of the funds available, with the ultimate expectation of protecting the entire city front. The work of protection will consist in covering the caving bank with brush mattresses loaded with stone, extending from above low-water out to the maximum depth.

Amount appropriated by act approved June 18, 1878	$46,000 00
July 1, 1878, amount available	46,000 00
Amount (estimated) required for completion of existing project	124,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.	124,000 00

(See Appendix L 7.)

8. *Improvement of the harbor and of Mississippi River at Vicksburg, Mississippi.*—It is intended to apply the appropriation to the protection of the Delta Point, as recommended by the Board of Engineers, whose report will be found in Appendix L 8.

This protection will consist in covering the bank with brush mattresses loaded with stone, extending along the bottom of the river out about 150 feet; the object being to hold the Delta Point where it is now by stopping the caving, and thus keep the deep water of the harbor from receding farther from the city landing.

Amount appropriated by act approved June 18, 1878	$84,000 00
July 1, 1878, amount available	84,000 00
Amount (estimated) required for completion of existing project	170,100 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.	90,000 00

(See Appendix L 8.)

9. *Water-gauges on the Mississippi River and its principal tributaries.*—There being no appropriation for this year, operations were continued until the funds were exhausted in October, when the observations were stopped. Many of the observers, however, kept up their readings without compensation, whereby continuous records have been obtained.

It is proposed the coming year to repair such gauges as need it, and to continue the observations of the rise and fall of the Mississippi and its tributaries.

July 1, 1877, amount available	$1,668 24	
Amount appropriated by act approved June 18, 1878	5,000 00	
		$6,668 24
July 1, 1877, amount expended during fiscal year		1,668 24
July 1, 1878, amount available		5,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		5,000 00

(See Appendix L 9.

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

To comply with provisions of the river and harbor act of June 18, 1878, Captain Benyaurd has been charged with and is now engaged upon examinations and surveys at the following localities, the results of which will be duly submitted when received:

1. *Big Sunflower River, Mississippi.*
2. *Tallahatchie River, Mississippi.*
3. *Cold Water River, Mississippi.*
4. *Bayou Bartholomew, Arkansas.*
5. *Upper Red River, from the raft up to the Missouri, Kansas and Texas Railroad bridge.*
6. *Little River, Arkansas.*
7. *Saline River, Arkansas.*

8. *Fouche La Faive, in Arkansas.*
9. *Tone's Bayou, Bayous Pierre and Wincey and Lakes Bayou Pierre and Cannasanier, Louisiana.*
10. *For improving the navigation at the Falls on Red River near Alexandria, Louisiana.*

REMOVING SNAGS AND WRECKS FROM MISSISSIPPI, MISSOURI, AND ARKANSAS RIVERS—SURVEYS AND IMPROVEMENTS AT VARIOUS POINTS ON MISSOURI RIVER—SURVEY OF MISSOURI RIVER FROM ITS MOUTH TO SIOUX CITY—IMPROVEMENT OF ARKANSAS RIVER AT FORT SMITH, AND OF WHITE RIVER AT BUFFALO SHOALS.

Officer in charge, Maj. C. R. Suter, Corps of Engineers.

1. *Removing snags and wrecks from the Mississippi, Missouri, and Arkansas Rivers.*—No appropriation having been made for rivers and harbors in 1877, the balance remaining from the appropriation of August 14, 1876, was retained for the care of the boats and other government property belonging to the work; field operations being limited to one month's snagging in the Missouri River.

A special appropriation made for the work (act approved February 7, 1878) enabled field operations to be resumed, and two boats were engaged on the three rivers until the close of the fiscal year.

On the Mississippi the work extended from the mouth of the Missouri to Vicksburg, 846 miles; on the Missouri, from the mouth to Lexington, 317 miles; and on the Arkansas, from the mouth to Little Rock, 280 miles.

During the coming season the field operations contemplate assigning eleven months to the Mississippi, three months to the Arkansas, and eight months to the Missouri. It is also intended to replace the hulls of two of the snag-boats which are now worn out.

The officer in charge recommends that one of the remaining wooden snag-boats be repaired and fitted up for wrecking purposes, and that the other receive an iron hull. Estimates for the purpose are submitted.

Amount required for fiscal year ending June 30, 1880.

For building one small iron-hulled snag-boat to carry the machinery of one of the present wooden boats		$105,000 00
For repairing one wooden snag-boat and fitting it up for wrecking purposes		50,000 00
For completion of the two iron snag-boats now authorized		30,000 00
For working expenses of five boats, 10 months each, at $4,000 per month		200,000 00
Total		385,000 00
July 1, 1877, amount available	$9,174 79	
Amount appropriated by act approved February 7, 1878	40,000 00	
Amount appropriated by act approved June 18, 1878, viz:		
For Mississippi and Arkansas Rivers	170,000 00	
For Missouri River	70,000 00	
		$289,174 79
July 1, 1878, amount expended during fiscal year		39,037 44
July 1, 1878, amount available		250,137 35
Amount that can be profitably expended in fiscal year ending June 30, 1880, viz:		
For Mississippi and Arkansas Rivers		$260,000 00
For Missouri River		125,000 00
		385,000 00

(See Appendix M 1.)

2. *Improvement of Missouri River at Fort Leavenworth, Kansas.*—A heavy and threatening erosion of the Missouri shore at this locality renders some kind of bank protection necessary, in constructing which it is proposed to expend the appropriation now available. No survey of the locality has yet been made, and until this is done no estimate for the completion of the work can be given.

Amount appropriated by act approved June 18, 1878	$25,000 00
July 1, 1878, amount available	25,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.	35,000 00

(See Appendix M 2.)

3. *Improvement of Missouri River at Atchison, Kansas.*—The survey made at this locality last season developed the necessity of protecting the Missouri shore for some distance above the railroad-bridge in order to prevent further encroachments of the river which threatened the safety of the bridge, and also to prevent changes in the channel which would render the bridge impassable for vessels. The plan proposed contemplates a revetment of brush mattresses along the exposed bank. The appropriation made for work at this point is smaller than the estimate, and as extensive changes will probably take place during the present high-water, a resurvey has been ordered to decide how the funds appropriated can be expended to the best advantage, and also to enable estimates to be made for the prosecution and completion of the work.

Amount appropriated by act approved June 18, 1878	$20,000 00
July 1, 1878, amount available	20,000 00
Amount (estimated) required for completion of existing project	100,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.	100,000 00

(See Appendix M 3.)

4. *Improvement of Missouri River opposite Saint Joseph, Missouri.*—The object of this improvement is to stop the erosion of the Kansas shore opposite the city of Saint Joseph, which, if allowed to go on unchecked, threatens to cut off a narrow neck or peninsula, taking the river away from the city and seriously endangering the railroad-bridge across the Missouri River at that point.

The balance of the allotment of $10,000 from the appropriation for the improvement of Mississippi, Missouri, and Arkansas Rivers was expended during the past season in strengthening and protecting the dikes already erected by the bridge company, and in protecting the banks near these dikes by a revetment of brush mattresses. The work, so far as carried out, was very satisfactory, and it is proposed, during the coming season, to continue the revetment as far as the funds appropriated will allow.

July 1, 1877, amount available	$9,098 81	
Amount appropriated by act approved June 18, 1878	50,000 00	
		$59,098 81
July 1, 1878, amount expended during fiscal year		9,098 81
July 1, 1878, amount available		50,000 00
Amount (estimated) required for completion of existing project		18,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		18,000 00

(See Appendix M 4.)

5. *Improvement of Missouri River at Nebraska City, Nebraska, and Eastport, Iowa.*—The object of this improvement is to change the position of the river channel, in order to restore the water-front of Nebraska City, and to check a severe bank erosion of the Iowa shore near Eastport.

The small amount available last year would only allow of the construction of a floating dike near the head of Copeland's Bend, by means

of which it was hoped that the desired change in the position of the channel might be at least initiated. Owing to the lateness of the season the work was partially destroyed by ice before its effects were fully developed, so that the results obtained, although encouraging, were only partially successful.

Before commencing operations during the coming season, it has been deemed advisable to resurvey the locality, in order to determine the effects of the summer's flood on the Missouri River. Until the results of this survey are available, and a definite plan is decided upon, estimates for the completion of the work cannot be submitted.

July 1, 1877, amount available	$11,700 57	
Amount appropriated by act approved June 18, 1878, viz:		
For improving the Missouri River at Nebraska City, Nebr	20,000 00	
For the improvement of the Missouri River at Eastport, Iowa, and Nebraska City, Nebr	20,000 00	
		$51,700 57
July 1, 1878, amount expended during fiscal year		11,700 57
July 1, 1878, amount available		40,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		85,000 00

(See Appendix M 5.)

6. *Improvement of Missouri River at Omaha, Nebraska, and Council Bluffs, Iowa.*—The survey made last year at this locality showed that, owing to a recently formed cut-off, the banks of the river near Council Bluffs and Omaha were being eroded with very great rapidity, and that much valuable property, including the railroad-bridge over the Missouri at Omaha, was threatened with destruction. A plan and estimate were submitted for the protection of the exposed bank near Omaha, where the threatened and actual damage was the greatest.

The summer's flood on the Missouri has made great changes, so that it is somewhat doubtful whether the plan originally proposed will be the most judicious for the expenditure of the present appropriation. To settle this point a resurvey will be needed, and will be taken in hand at once.

Amount appropriated by act approved June 18, 1878, viz:		
For the improvement of the Missouri River at Council Bluffs, Iowa, and Omaha, Nebr	$50,000 00	
For improving the Missouri at Omaha City, Nebr	30,000 00	
		$80,000 00
July 1, 1878, amount available		80,000 00
Amount (estimated) required for completion of existing project		130,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		130,000 00

(See Appendix M 6.)

7. *Improvement of Missouri River at Sioux City, Iowa.*—A survey of this locality was made in May, 1878, and a plan submitted for checking the erosion of the bank in front of the city by a revetment of brush mattresses extending along the most important portion of the city front.

A resurvey of the locality will be made to determine whether any change of plan is necessary.

Amount appropriated by act approved June 18, 1878	$12,500 00
July 1, 1878, amount available	12,500 00
Amount (estimated) required for completion of existing project	33,774 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.	33,800 00

(See Appendix M 7.)

8. *Survey of Missouri River from its mouth to Sioux City, and estimates for the improvement and maintenance of its navigation.*—Major Suter is charged with the execution of this survey, which will be taken in hand as soon as possible. The appropriation of $50,000 made for the work will all be expended during the coming season, and the survey will be carried as high as Leavenworth, Kans. For the completion of the survey $50,000 will be required.

Amount appropriated by act approved June 18, 1878	$50,000 00
July 1, 1878, amount available	50,000 00
Amount (estimated) required for completion of existing project	50,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.	50,000 00

(See Appendix M 8.)

9. *Improvement of Arkansas River at Fort Smith, Arkansas.*—During the past season the balance of the allotment of $10,000 from the appropriation for improving Mississippi, Missouri, and Arkansas rivers was expended in constructing a dike, designed to remove a bar which obstructs the landing at Fort Smith, Ark., and is also in the way of boats which have to pass above Fort Smith. The results obtained were very satisfactory, and the dike, although incomplete, has withstood a heavy flood without material injury.

During the coming season it is proposed to lengthen the dike, and also increase its height and width, for which purpose the present appropriation will suffice. When this work is completed, it is thought that the object of the improvement will be attained, and that no further appropriation will be necessary.

July 1, 1877, amount available	$9,695 49	
Amount appropriated by act approved June 18, 1878	10,000 00	
		$19,695 49
July 1, 1878, amount expended during fiscal year		9,695 49
July 1, 1878, amount available		10,000 00

(See Appendix M 9.)

10. *Improvement of White River, at Buffalo Shoals, Arkansas.*—The object of this improvement is to deepen the channel where it flows with great velocity over a long, rocky shoal. The bed is of solid rock, covered with loose bowlders, and the low-water depth is about 6 inches.

The plan approved contemplates the construction of 7 spur-dikes, so located as to hold back and deepen the water on the shoalest places, and also the removal of rock and bowlders, so as to leave a clear channel of 200 feet in width. Work has been much delayed during the past season by high water, and is still in progress, only three of the proposed dikes being completed.

The balance of the appropriation of $10,000, made by act approved August 14, 1876, will be expended in removing some of the worst obstructions from the channel, and after this is done the work must cease, as no appropriation has been made for continuing it.

For completing the work, an additional appropriation of $10,000 will be required.

July 1, 1877, amount available	$9,816 67	
July 1, 1878, amount expended during fiscal year	8,140 17	
July 1, 1878, amount available		$1,676 50
Amount (estimated) required for completion of existing project		10,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		10,000 00

(See Appendix M 10.)

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

An allotment was made from the appropriation of August 14, 1876, for Mississippi, Missouri, and Arkansas Rivers, for *surveys and examinations for improvements on the Missouri River at Omaha and Council Bluffs, and at Plattsmouth, Brownville, Atchison, and Sioux City.*

Major Suter was charged with the execution of these surveys, and his reports thereon, with the exception of the last named, were transmitted to Congress at its last session, and printed in Senate Ex. Doc. No. 30. They will all be found in Appendixes M 11 and M 12 of this report.

To comply with provisions of the river and harbor act of June 18, 1878, Major Suter has been charged with and is now engaged upon examinations and surveys at the following localities, the results of which will be duly submitted when received:

1. *The Missouri River at Cedar City, in Callaway County, Missouri.*
2. *Missouri River at the City of Saint Charles, Missouri.*
3. *The Arkansas River from Fort Smith, Arkansas, to the mouth of Little Arkansas.*
4. *The Missouri and Kansas Rivers at and near their junction.*
5. *The Kansas River from its mouth to Junction City, Kansas.*

IMPROVEMENT OF MISSISSIPPI RIVER BETWEEN THE MOUTHS OF THE ILLINOIS AND OHIO RIVERS—IMPROVEMENT OF OSAGE RIVER.

Officer in charge, Col. J. H. Simpson, Corps of Engineers, having under his immediate orders Capt. Chas. J. Allen, Corps of Engineers.

1. *Improvement of Mississippi River—Piasa and Alton Dams.*—The funds available for these works were—

Balance July 1, 1877	$10,561 72

which was applied to the construction of Piasa Dam and the revetment of the head of Piasa Island, and repairs and extension of the abutments of Alton Dam, as follows:

Piasa Dam and revetment of Piasa Island	$8,596 93
Alton Dam	1,559 07
	10,156 00

Owing to favorable conditions, these dams are now virtually complete, leaving the $20,000 required by the terms of the act approved June 18, 1878, to be expended between the Illinois and Missouri, available for any new work which may be thought advisable after examination of the river at a lower stage than prevailed at the time this report was made.

Sawyer and Venice Bends.—A small amount of work was done at Sawyer Bend, rendered necessary to preserve the work; but no extension of the protection has been possible since 1875, for want of funds. It is intended to resume work the present season to a limited extent.

No work was done near Venice, and none is contemplated.

Closing Cahokia Chute.—At the beginning of the fiscal year a balance of $8,641.39 remained applicable to this work. The revetments were extended and repaired, to preserve the site of the proposed dam, but no work has yet been done upon the dam itself.

The act approved June 18, 1878, having provided the full amount of the estimate for the dam, $75,000, it is hoped that during the year it will be well advanced toward completion.

Horsetail Bar.—The results of the work at this locality of previous years were on the whole satisfactory during the past season. For a

few days a serious difficulty in navigation existed, due, in a great measure, to changes resulting from the work, then in progress, of restoring one of the dikes which had settled. After this temporary disturbance was removed, the channel opened and gradually improved; a result which it is hoped to maintain hereafter.

As the training-wall, commenced last season, progresses, the permanence of the improvement will be secured. After maintaining the dikes, the work of the coming season will be the extension of this training-wall.

Fort Chartres and Turkey Island.—No work was done on these dams during the past year, and none is contemplated the present fiscal year.

The protection of Fish Bend is essential to the permanent realization of the benefits expected to result from these dams.

Kaskaskia Bend.—The results of the work last year are unsatisfactory. The small amount set apart for the work by the terms of the appropriation did not allow the work to progress far enough to be secure, and it is feared that it is destroyed.

The appropriation of June 18, 1878, sets apart $10,000, which it has been deemed advisable to supplement by an additional allotment of $10,000 from the funds left to be distributed by the department. With this amount the work can be secured.

Further appropriations will be much needed to continue the work.

Liberty Island.—This work was untouched during the past fiscal year, and, as a consequence, the upper part of the partially-completed revetment has received material injury. The caving has extended up stream, rendering extension and restoration necessary.

An allotment of $20,000 has been made for the present fiscal year.

Devil's Island.—The dams at this island are reported to be practically complete, and it is not intended to commence additional works.

The channel during the year remained in good condition, affording no difficulty to skillful and capable navigation.

Dickey Island to Cairo.—The results of the previous year's work have been maintained and secured by such extension of the protection as the means allowed to be made. These results are gratifying, as the locality afforded a severe test of the proposed plan.

Work will be continued to the full extent the means recently provided will allow, and it is hoped further appropriations will be made, that the work may progress until complete.

The officer in charge submits an estimate of $500,000 for the fiscal year ending June 30, 1880. This sum would complete all the works now in progress and allow some new ones to be begun.

The appropriation of the above sum is recommended.

July 1, 1877, amount available	$106,404 14	
Amount appropriated by act approved June 18, 1878	240,000 00	
		$346,404 14
July 1, 1878, amount expended during fiscal year	90,096 52	
July 1, 1878, outstanding liabilities	1,274 48	
		91,371 00
July 1, 1878, amount available		255,033 14
Amount (estimated) required for completion of existing project		6,489,600 00
Amount that can be profitably expended in fiscal year ending June 30, 1880		500,000 00

(See Appendix N 1.)

2. *Improvement of Osage River.*—Work upon this river has been suspended during three years just past; but the act approved June 18, 1878,

having provided the sum of $20,000 for its further improvement, work will be resumed during the coming season.

There being no definite project in progress, no statement of estimated amount to complete existing project can be given, and no sum recommended for the fiscal year ending June 30, 1880.

Amount appropriated by act approved June 18, 1878	$20,000 00
July 1, 1878, amount available	20,000 00

(See Appendix N 2.)

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

To comply with provisions of the river and harbor act of June 18, 1878, Colonel Simpson has been charged with and is now engaged upon examinations and surveys at the following localities, the results of which will be duly submitted when received.

1. *The Mississippi River, to ascertain the practicability, cost, and utility of a dike from Bloody Island, opposite the city of Saint Louis, Mo., north to the dike or dam opposite Brooklyn, on the Illinois shore.*

2. *A survey and estimate of the damages, if any, done, or to be done, to riparian owners of lands and improvements thereon, at or in front of the town of Venice, Ill., near Saint Louis, Mo., by reason of government improvements made, or to be made, at or near said town of Venice.*

IMPROVEMENT OF MISSOURI RIVER ABOVE MOUTH OF THE YELLOWSTONE.

Officer in charge, Lieut. Edward Maguire, Corps of Engineers.

At Dauphin's Rapids a channel 100 feet wide and 1,800 feet long has been cleared of rocks.

A dam 130 feet in length containing 200 cubic yards of stone, and three short dams containing about 60 cubic yards of stone, have been built.

At Cow Island all of the rocks were removed from the channel, and a dam built 419 feet long, containing 710 cubic yards of stone.

The results of last season's work are apparently favorable.

During the coming season the work at Dauphin's Rapids will be continued by one party. Another party will complete the projected improvement at Cow Island, and thence proceed to Grand Island and Two Calf Island.

July 1, 1877, amount available	$14,459 63	
Amount appropriated by act approved June 18, 1878	30,000 00	
		$44,459 63
July 1, 1878, amount expended during fiscal year	10,838 50	
July 1, 1878, outstanding liabilities	23 50	
		10,862 00
July 1, 1878, amount available		33,597 63
Amount that can be profitably expended in fiscal year ending June 30, 1880		55,000 00

(See Appendix O.)

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

To comply with provisions of the river and harbor act of June 18, 1878, Lieutenant Maguire has been charged with and is now engaged upon an examination and survey of the *Yellowstone River*, the result of which will be duly submitted *when received.*

WORKS OF IMPROVEMENT AT VARIOUS POINTS ON THE UPPER MISSISSIPPI RIVER BELOW SAINT PAUL; IMPROVEMENT OF GALENA, MINNESOTA, CHIPPEWA, AND SAINT CROIX, RIVERS, AND OF RED RIVER OF THE NORTH; PRESERVATION OF THE FALLS OF SAINT ANTHONY AND IMPROVEMENT OF THE MISSISSIPPI ABOVE THE FALLS.

Officer in charge, Maj. F. U. Farquhar, Corps of Engineers. The works enumerated in this section, from 1 to 6, inclusive, were in charge of Col. J. N. Macomb, Corps of Engineers, until November 15, 1877.

1. *Improvement of Upper Mississippi River.*—During the year the United States snag-boat Montana was employed as in former years in removing snags and other obstructions, in making surveys for future improvements, and in assisting stranded steamboats. During the winter a map of the river from Falls of Saint Anthony to the mouth of the Illinois River was prepared for publication and distribution among river men.

Observations were made for recording the lowest water during the low-water season (lowest known except 1864), and the elevation of "low water of 1877" was obtained and referred to permanent bench-marks at 61 stations.

A reconnaissance of the Mississippi River was made between the mouth of the Illinois and Des Moines Rapids, and some of the worst bars were examined.

It is proposed, with the funds available, to operate the *Montana* during the season of navigation, and in the winter build a new hull and transfer her machinery to it.

The officer in charge asks for an appropriation of $30,000 for operating the snag-boat for the fiscal year ending June 30, 1880.

July 1, 1877, amount available	$16,752 21	
Amount appropriated by act approved June 18, 1878	41,500 00	
		$58,252 21
July 1, 1878, amount expended during fiscal year	14,663 03	
July 1, 1878, outstanding liabilities	850 21	
		15,513 24
July 1, 1878, amount available		42,738 97
Amount that can be profitably expended operating snag-boat in fiscal year ending June 30, 1880		30,000 00

(See Appendix P 1.)

2. *Improvement of Rock Island Rapids in Mississippi River.*—During the months from July to November, 1877, 1,052 cubic yards of rock were broken by the chisel at the foot of Moline Chain. Adding to this amount the number of cubic yards broken in the fall of 1876 and in June, 1877, it leaves 1,207 cubic yards to be removed the present season, and in addition there remains to be dredged 2,505 cubic yards of rock.

The amount of $30,000 appropriated for the fiscal year ending June 30, 1879, will not be sufficient to close the work, and an appropriation of $20,000 will be required for the fiscal year ending June 30, 1880, to complete it.

July 1, 1777, amount available	$14,762 87	
Amount appropriated by act approved June 18, 1878	30,000 00	
		$44,762 87
July 1, 1878, amount expended during fiscal year	11,505 00	
July 1, 1878, outstanding liabilities	406 50	
		11,911 50
July 1, 1878, amount available		32,851 37
Amount (estimated) required for completion of existing project		20,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		20,000 00

(See Appendix P 2.)

3. *Protection of the piers at Rock Island Bridge by means of sheer-booms.*—Two sheer-booms have been constructed. One 750 feet long, furnished with rudders to maneuver it, was placed above the right pier of the left raft-span, and one 400 feet long was hung to a crib, to keep vessels from striking the rocks above the left draw-span of the United States Government bridge.

The total cost of the booms was $11,717.95.

July 1, 1877, amount available		$15,000 00
July 1, 1878, amount expended during fiscal year	$11,453 58	
July 1, 1878, outstanding liabilities	264 37	
		11,717 95
July 1, 1878, amount available		3,282 05

(See Appendix P 3.)

4. *Improvement of harbor at Fort Madison, Iowa.*—Work during the year consisted in the partial construction of a dam across the head of Niota Chute and some shore protection at both ends of the dam.

It is proposed during the present season to complete the dam, for which about 2,500 cubic yards of rock will be necessary.

July 1, 1877, amount available	$9,636 57	
Amount appropriated by act approved June 18, 1878	8,000 00	
		$17,636 57
July 1, 1878, amount expended during fiscal year	9,341 83	
July 1, 1878, outstanding liabilities	257 75	
		9,599 58
July 1, 1878, amount available		8,036 99
Amount (estimated) required for completion of existing project		12,186 87
Amount that can be profitably expended in fiscal year ending June 30, 1880.		12,186 87

(See Appendix P 4.)

5. *Improvement of Rush Chute and of harbor at Burlington, Iowa.*—Work during the year consisted in the partial construction of a brush and stone dam from the head of Rush Island to Otter Island, and some 400 feet of shore-protection on Rush and Otter islands.

It is proposed during the present season to finish the dam, for which 2,839 cubic yards of rock will be required, and to do such work as may be necessary below the head of the chute, as far as funds available will go.

July 1, 1877, amount available	$9,927 79	
Amount appropriated by act approved June 18, 1878	10,000 00	
		$19,927 79
July 1, 1878, amount expended during fiscal year	9,793 78	
July 1, 1878, outstanding liabilities	100 00	
		9,893 78
July 1, 1878, amount available		10,034 01
Amount (estimated) required for completion of existing project		15,221 70
Amount that can be profitably expended in fiscal year ending June 30, 1880.		15,221 70

(See Appendix P 5.)

6. *Removal of bar in the Mississippi River opposite Dubuque, Iowa.*—During the year 39,261 cubic yards of sand were dredged from the bar in front of the steamboat landing. With the funds available the dredging will be continued during the present season. Not less than $13,125 should be appropriated for the fiscal year *ending June 30, 1880.*

July 1, 1877, amount available	$14,416 82	
Amount appropriated by act approved June 18, 1878	10,000 00	
		$24,416 82
July 1, 1878, amount expended during fiscal year		14,383 65
July 1, 1878, amount available		10,033 17
Amount (estimated) required for completion of existing project		13,125 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		13,125 00

(See Appendix P 6.)

7. *Improvement of Mississippi River from the bridge of the Chicago, Milwaukee and Saint Paul Railroad, above La Crosse, Wisconsin, to the mouth of Root River, below said city.*—With the appropriation of June 18, 1878, it is proposed to close the chute on both sides of Bates' Island and to protect the head of Grand Island. The amount appropriated will complete this work.

Amount appropriated by act approved June 18, 1878	$12,500 00
July 1, 1878, amount available	12,500 00

(See Appendix P 7.)

A communication from the mayor of La Crosse having been referred to this office by the honorable Secretary of War, urging on behalf of the citizens of that place that some action be immediately taken to avert what seemed to them an impending calamity caused by the change in the channel of the Mississippi in their vicinity, the Board of Engineer Officers constituted in 1875 to report upon the location of the Chicago, Milwaukee and Saint Paul Railroad bridge was reconvened to report upon the condition of the channel-way and the causes of the changes that were taking place in the bed of the stream, and to recommend such works and measures as might be considered proper for the United States to undertake to restore the channel to its former position.

The report of the board will be found in Appendix P 7.

8. *Improvement of Galena River and of harbor at Galena, Illinois.*—The appropriation of June 18, 1878, will be expended in dredging, and it is expected will be sufficient to remove about 60,000 cubic yards.

The officer in charge recommends an appropriation of $100,000 to continue this dredging during the fiscal year ending June 30, 1880, but, from want of information as to the necessity of so large an amount, it has been reduced in this office to $30,000.

Amount appropriated by act approved June 18, 1878	$30,000 00
July 1, 1878, amount available	30,000 00
Amount (estimated) required for completion of existing project	370,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880, as revised in this office	30,000 00

(See Appendix P 8.)

9. *Widening and deepening the channel of Mississippi River from Des Moines Rapids to the mouth of the Illinois.*—It is proposed to make a thorough survey of the river between Des Moines Rapids and the mouth of the Illinois River.

The officer in charge recommends an appropriation of $100,000 for the fiscal year ending June 30, 1880, for the continuation of whatever plan may be adopted for the improvement of the low-water navigation of the river between these points.

Amount appropriated by act approved June 18, 1878	$100,000 00
July 1, 1878, amount available	100,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.	100,000 00

(See Appendix P 9.)

10. ***Widening and deepening the channel of Mississippi River from Saint Paul to Des Moines Rapids.***—Work has been commenced in localities where the worst obstructions to navigation exist.

In the last annual report from this office a preliminary estimate was submitted for a comprehensive system of improvement, amounting to $617,393. The officer in charge recommends an appropriation of $250,000 for its prosecution during the fiscal year ending June 30, 1880.

Amount appropriated by act approved June 18, 1878	$250,000 00
July 1, 1878, amount available	250,000 00
Amount (estimated) required for completion of existing project	367,393 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.	250,000 00

(See Appendix P 10.)

11. *Improvement of Falls of Saint Anthony.*—The small exploring drift below the concrete dike was completed and the leakage taken into a drain.

The west slope of the apron was removed and a new apron built in the plane of the center slope and the excavation at the foot of the apron filled with rock.

The apron was also extended 85 feet along the west side of Hennepin Island.

The only work that remains to be done is a wall to protect the sand rock at the west side of the apron and some slight changes in the dam west of Hennepin Island. Sufficient funds are on hand to complete the work.

July 1, 1877, amount available		$58,498 40
July 1, 1878, amount expended during fiscal year	$46,795 01	
July 1, 1878, outstanding liabilities	290 00	
		47,085 01
July 1, 1878, amount available		11,413 39

(See Appendix P 11.)

12. *Improvement of Mississippi River above the Falls of Saint Anthony.*—During the season of 1877 all bowlders were removed from the channel from the head of Smilar's Rapids to Itaska, a distance of 27 miles.

In the same distance 2,771 linear feet of brush and stone dams and 1,190 linear feet of shore protection were constructed.

During the present season the removal of bowlders will be continued as far as Minneapolis and the brush dams built in 1874 will be repaired.

The officer in charge suggests that, if the work is to go on, at least $50,000 be appropriated annually.

July 1, 1877, amount available		$16,710 02
July 1, 1878, amount expended during fiscal year	$8,387 92	
July 1, 1878, outstanding liabilities	1,494 67	
		9,882 59
July 1, 1878, amount available		6,827 43
Amount (estimated) required for completion of existing project		124,667 50
Amount that can be profitably expended in fiscal year ending June 30, 1880.		50,000 00

See Appendix P 12.)

13. *Construction of lock and dam on Mississippi River at Meeker's Island, Minnesota.*—The parties holding the land-grant not having made any acceptable release, as required by act approved March 3, 1875, no work has been done here, as the funds were not available.

July 1, 1877, amount available	$25,000 00
July 1, 1878, amount available	25,000 00
Amount (estimated) required for completion of existing project	922,121 46

(See Appendix P 13.)

14. *Improvement of Minnesota River.*—Snags and overhanging trees were removed from 29½ miles of the river below Saint Peter, the work being done by contract. There is no commerce on the river above Little Rapids at stages of low water, nor will there be until the creation of slack-water navigation. At least $60,000 will be required to commence the lower lock at Little Rapids.

July 1, 1877, amount available	$9,963 36	
Amount appropriated by act approved June 18, 1878	10,000 00	
		$19,963 36
July 1, 1878, amount expended during fiscal year	9,727 95	
July 1, 1878, outstanding liabilities	222 00	
		9,949 95
July 1, 1878, amount available		10,013 41

(See Appendix P 14.)

15. *Improvement of Chippewa River, Wisconsin.*—The west jetty at the mouth of the river has been completed, and 405 feet of the east jetty built, the work being done by contract. The channel has been greatly improved, and after the completion of the east jetty there will be a depth of 4 feet at low water. During the present season the east jetty will be completed, and a training-dam built above the head of the jetties. The five high sand-banks below Eau Claire should be protected, and the work of building wing-dams and jetties carried on. For the first work $64,000 is estimated to be required, and for the latter, $20,000.

July 1, 1877, amount available	$9,971 82	
Amount appropriated by act approved June 18, 1878	10,000 00	
		$19,971 82
July 1, 1878, amount expended during fiscal year	9,881 18	
July 1, 1878, outstanding liabilities	50 00	
		9,931 18
July 1, 1878, amount available		10,040 64
Amount (estimated) required for completion of existing project		119,892 50
Amount that can be profitably expended in fiscal year ending June 30, 1880, for constructing wing-dams and jetties		20,000 00

(See Appendix P 15.)

16. *Improvement of Red River of the North.*—All snags, drift-piles, and overhanging trees were removed from Moorhead to 1 mile north of Frog Point, a distance of 120 miles by river.

An examination of the river was made from Frog Point to the northern boundary-line.

July 1, 1877, amount available	$8,545 37	
Amount appropriated by act approved June 18, 1878	30,000 00	
		$38,545 37
July 1, 1878, amount expended during fiscal year	6,960 66	
July 1, 1878, outstanding liabilities	20 00	
		6,980 66
July 1, 1878, amount available		31,564 71
Amount (estimated) required for completion of proposed project		190,000 00
Amount that can be profitably expended in fiscal year ending June, 30,1880.		112,000 00

(See Appendix P 16.)

17. *Improvement of Saint Croix River, Wisconsin.*—With amount appropriated by act of June 18, 1878, it is proposed to build the brush and stone dams and to remove submerged boom-piers estimated for in report of examination made in 1874 (see page 372, part 1, annual report of the Chief of Engineers, 1875), as far as the funds will permit.

The estimate for this improvement was $21,758.

Amount appropriated by act approved June 18, 1878	$10,000 00
July 1, 1878, amount available	10,000 00
Amount (estimated) required for completion of existing project	11,758 00
Amount that can be profitably expended in fiscal year ending June 30, 1880	11,758 00

(See Appendix P 17.)

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

To comply with provisions of the river and harbor act of June 18, 1878, Major Farquhar has been charged with and is now engaged upon examinations and surveys at the following localities, the results of which will be duly submitted when received.

1. *Mississippi River at and above the city of Alexandria, Missouri.*
2. *The harbor at Quincy, Illinois.*

The same act also provides for an *examination of the sources of the Mississippi River and of the Saint Croix River in Wisconsin and Minnesota, and of the Chippewa and Wisconsin rivers in the State of Wisconsin, to determine the practicability and cost of creating and maintaining reservoirs upon the headwaters of said rivers and their tributaries for the purpose of regulating the volume of water and improving the navigation of said rivers and that of the Mississippi River, and an estimate of the damage to result therefrom to property of any kind.* This has been assigned to Capt. C. J. Allen, Corps of Engineers, and is in progress.

IMPROVEMENT OF THE DES MOINES RAPIDS OF MISSISSIPPI RIVER.

Officer in charge up to November 16, 1877, Col. J. N. Macomb, Corps of Engineers, having under his immediate orders Capt. Amos Stickney, Corps of Engineers, since which the work has been in charge of Capt. Amos Stickney, Corps of Engineers.

During the first part of the season the work was principally confined to those portions which would permit the opening of the canal to navigation. The canal was opened to the public August 22, 1877, and has since been in constant use with the exception of about thirty days in the fall of 1877, when it was closed to make repairs to the lock miter-sills, and from December 10, 1877, to March 15, 1878, on account of the winter cessation of navigation on the upper river.

The work has consisted of finishing lock-gates and placing machinery; building face of riprap wall on canal embankment; clearing out cross-banks and obstructions at entrances of canal, and, since the opening, in operating and maintaining the work.

July 1, 1877, amount available	$105,650 30	
Amount appropriated by act approved April 30, 1878	7,500 00	
Amount appropriated by act approved June 18, 1878	95,000 00	
		$208,150 30
July 1, 1878, amount expended during fiscal year	102,861 15	
July 1, 1878, outstanding liabilities	5,328 65	
		108,189 80
July 1, 1878, amount available		99,960 50
Amount required (estimated) for completion of existing project—		
To replace operating expenses during year ending June 30, 1878	40,065 00	
To replace operating expenses during year ending June 30, 1879	40,000 00	
Additional	12,000 00	
		92,065 00
Amount required for operating and maintenance of canal for year ending June 30, 1880		40,000 00
Amount that can be profitably expended in year ending June 30, 1880		132,065 00

(See Appendix Q.)

IMPROVEMENT OF THE TENNESSEE AND CUMBERLAND RIVERS; OF COOSA RIVER, GEORGIA AND ALABAMA; OF HIAWASSEE RIVER, TENNESSEE; AND OF OCMULGEE, OOSTENAULA, COOSAWATTEE, ETOWAH, AND OCONEE RIVERS, GEORGIA.

Officer in charge, Capt. William R. King, Corps of Engineers, with Capt. L. Cooper Overman and Lieut. W. L. Marshall, Corps of Engineers, under his immediate orders.

1. *Improvement of Tennessee River.—a. Above Chattanooga.*—There being no funds applicable to this work, nothing was done during the fiscal year until the appropriation of June 18, 1878, became available, when steps were taken to reorganize working-parties and provide the necessary equipment of boats, tools, and other supplies.

It is hoped that before the close of the present low-water season considerable work will be done at Chota Shoals and other points below Knoxville. The improvement of this part of the river is very much needed, and the plan adopted is a continuation of that heretofore successfully applied on this river and elsewhere, and, owing to the exceptional permanence of the river-bed, the improvements, when once completed, will require only occasional minor repairs for many years to come.

There has been appropriated for this work $180,000. Of this amount $164,928.83 have been expended.

July 1, 1877, amount available	$167 28	
Amount appropriated by act approved June 18, 1878	15,000 00	
		$15,167 28
July 1, 1878, amount expended during fiscal year	96 11	
July 1, 1878, outstanding liabilities	71 17	
		167 28
July 1, 1878, amount available		15,000 00
Amount (estimated) required for completion of existing project		45,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		35,000 00

b. Below Chattanooga.—Work on this part of the river has been continued during the year, partly under contract and partly by hired labor.

The masonry of three locks, 300 feet long by 60 feet wide, has been completed, and the contractor for building five more locks of similar dimensions has made a beginning on four of the number.

Some heavy work in quarrying, channel excavation, &c., has been done by hired labor at Elk River, Little Muscle Shoals, and Colbert Shoals, of which the following are the principal items:

14,829 cubic yards of rock quarried for dams.
5,082 cubic yards of rock quarried and put in dams.
8,410 cubic yards of rock excavated from channel.

The officer in charge states that the work can probably be completed for a much smaller sum than originally estimated.

July 1, 1877, amount available	$431,670 96	
Amount appropriated by act approved June 18, 1878	300,000 00	
		$731,670 96
July 1, 1878, amount expended during fiscal year	213,643 46	
July 1, 1878, outstanding liabilities	20,059 58	
		233,703 04
July 1, 1878, amount available		497,967 92
Amount (estimated) required for completion of existing project		2,797,500 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		700,000 00

(See Appendix S 1.)

2. *Improvement of Cumberland River.—a. Below Nashville.*—No work was done on this section during the fiscal year, the available funds being exhausted. Working-parties are now organized for continuing work by hired labor at Harpeth Shoals, at Dover Island Shoals, and other points.

July 1, 1877, amount available	$336 63	
Amount appropriated by act approved June 18, 1878	45,000 00	
		$45,336 63
July 1, 1878, amount expended during fiscal year		328 00
July 1, 1878, amount available		45,008 63
Amount (estimated) required for completion of existing project		103,821 00
Amount that can be profitably expended in fiscal year ending June 30, 1880		70,000 00

Cumberland River above Nashville.—b. From Nashville to the Kentucky line.—Work on this section was carried on at Sand Shoals, Cub Creek Shoals, Bartlett's Bar, and Holliman's Island Shoals. At these points 3,508 cubic yards of rock and gravel were excavated from the channel; 91 logs and overhanging trees removed; 1,817 cubic yards of stone dams built; and 307 cubic yards of stone quarried for dams.

July 1, 1877, amount available	$7,182 27	
Amount appropriated by act approved June 18, 1878	20,000 00	
		$27,182 27
July 1, 1878, amount expended during fiscal year		7,174 46
July 1, 1878, amount available		20,007 81
Amount (estimated) required for completion of existing project		87,155 00
Amount that can be profitably expended in fiscal year ending June 30, 1880		60,000 00

c. From the Kentucky line to Smith's Shoals.—Work on this section was done at Wild Goose Shoals by excavating 3,258 cubic yards of rock and gravel from the channel; 350 snags and overhanging trees were also removed; 220 cubic yards of rock quarried, and 780 cubic yards of dam constructed.

July 1, 1877, amount available	$8,752 20	
Amount appropriated by act approved June 18, 1878	8,000 00	
		$16,752 20
July 1, 1878, amount expended during fiscal year		8,741 30
July 1, 1878, amount available		8,010 90
Amount (estimated) required for completion of existing project		73,609 00
Amount that can be profitably expended in fiscal year ending June 30, 1880		50,000 00

d. At Smith's Shoals.—The work carried on consisted of excavating 1,050 cubic yards of rock from channel; quarrying 1,620 cubic yards of stone; placing 9,600 cubic yards of stone in dams; and building 950 cubic yards of dam at Mill Shoal.

July 1, 1877, amount available	$17,572 89	
Amount appropriated by act approved June 18, 1878	30,000 00	
		$47,572 89
July 1, 1878, amount expended during fiscal year		17,625 52
July 1, 1878, amount available		29,947 37
Amount (estimated) required for completion of existing project		15,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880		15,000 00

e. From Smith's Shoals to the Falls of the Cumberland.—On this section about 1,650 cubic yards of rock, consisting of dangerous bowlders, &c., were removed from the channel.

July 1, 1877, amount available	$2,000 00	
Amount appropriated by act approved June 18, 1878	2,000 00	
		$4,000 00
July 1, 1878, amount expended during fiscal year		1,978 68
July 1, 1878, amount available		2,021 32

(See Appendix S 2.)

3. *Improvement of Hiawassee River.*—Good progress was made until the appropriation became nearly exhausted in October.

The work was carried on principally at Mathew's Shoals, Magil's Island Shoals, and Blackbird Shoals. About 403 cubic yards of rock and gravel were excavated from the channel, 879 cubic yards of rock quarried, and 2,784 cubic yards of rock were placed in dams. Also a large number of logs, bowlders, &c., were removed. Work was resumed in June.

July 1, 1877, amount available	$9,718 80	
Amount appropriated by act approved June 18, 1878	10,000 00	
		$19,718 80
July 1, 1878, amount expended during fiscal year		9,678 75
July 1, 1878, amount available		10,040 05
Amount (estimated) required for completion of existing project		10,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880		10,000 00

(See Appendix S 3.)

4. *Improvement of Coosa River, Georgia and Alabama.*—In consequence of continued high-water, operations were carried on only during six months of the fiscal year at Horseleg Shoals, Turkey Town Island Shoals, Copperas Bluffs, Cross Shoals, Greensport Reefs, and Mill Shoals. The work done at these points consisted of excavating 1,679 cubic yards of rock and gravel and removing 29 dangerous snags from the channel, and in building 894 linear feet of riprap dams, 1,525 linear feet of crib-dams, and 300 linear feet of brush and gravel dams. A large quantity of rock was also quarried for building dams.

A careful survey was made of Whistenant's Shoals and Ten Island Shoals, in order to locate the dams and locks necessary for their improvement. Plans and specifications of the locks are ready, and the lock-work will be placed under contract at once.

July 1, 1877, amount available	$29,760 59	
Amount appropriated by act approved June 18, 1878	75,000 00	
		104,760 59
July 1, 1878, amount expended during fiscal year	15,911 26	
July 1, 1878, outstanding liabilities	1,805 74	
		17,717 00
July 1, 1878, amount available		87,043 59
Amount (estimated) required for completion of existing project		447,347 00
Amount that can be profitably expended in fiscal year ending June 30, 1880		150,000 00

(See Appendix S 4.)

5. *Improvement of Oostenaula and Coosawattee Rivers, Georgia.*—No work was done during the fiscal year for want of funds.

Preparations are being made to repair and extend the wing-dams, where most needed, during the present low water season.

Amount appropriated by act approved June 18, 1878	$4,000 00
July 1, 1878, amount available	4,000 00
Amount (estimated) required for completion of existing project	9,208 50
Amount that can be profitably expended in fiscal year ending June 30, 1880	9,208 50

(See Appendix S 5.)

6. *Improvement of Etowah River, Georgia.*—An examination of this river was made in July, 1877. The appropriation available being so small and the work to be done so extensive, no economical expenditure of the amount could be devised. A special allotment having been made for an instrumental survey of this river, a specific project with estimates will be submitted as soon as practicable.

July 1, 1877, amount available		$10,000 00
July 1, 1878, amount expended during fiscal year		59 73
July 1, 1878, amount available		9,940 27
Amount (estimated) required for completion of existing project. (Project incomplete.)		

(See Appendix S 6.)

7. *Improvement of Ocmulgee River, Georgia.*—During the fiscal year about 420 snags have been removed from the channel, and 360 overhanging trees have been cut down and removed out of reach of high water. The channel has been straightened and deepened at various places above and below Hawkinsville.

July 1, 1877, amount available	$14,953 33	
Amount appropriated by act approved June 18, 1878	15,000 00	
		$29,953 33
July 1, 1878, amount expended during fiscal year	12,966 02	
July 1, 1878, outstanding liabilities	484 55	
		13,450 57
July 1, 1878, amount available		16,502 76
Amount (estimated) required for completion of existing project		26,240 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		26,240 00

(See Appendix S 7.)

8. *Improvement of Oconee River, Georgia.*—The appropriation of June 18, 1878, being the first one applicable to this river, no work has yet been done, but preparations are now being made for commencing the work of clearing the channel of logs; of cutting down overhanging trees; and making "cut-offs" between bends of the river where most advantageous.

Amount appropriated by act approved June 18, 1878	$10,000 00
July 1, 1878, amount available	10,000 00
Amount (estimated) required for completion of existing project	5,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.	5,000 00

(See Appendix S 8.)

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

To comply with provisions of the river and harbor act of June 18, 1878, Captain King has been charged with and is now engaged upon examinations and surveys at the following localities, the results of which will be duly submitted when received

1. *Caney's Fork and Obey's Rivers, Tennessee.*
2. *Etowah River, Georgia.*
3. *The Falls of the Cumberland, Kentucky.*
4. *Chattahoochee River, Georgia, above Columbus.*

IMPROVEMENT OF THE NAVIGATION AT THE FALLS OF OHIO RIVER—SUPERINTENDENCE AND MANAGEMENT OF THE LOUISVILLE AND PORTLAND CANAL.

Officer in charge, Maj. G. Weitzel, Corps of Engineers, with Capt. A. Nisbet Lee, Corps of Engineers, under his immediate orders.

During the temporary absence of Major Weitzel, from May 15, 1878, these works were under the charge of Capt. Alexander Mackenzie, Corps of Engineers.

1. *Improvement of the Falls of Ohio River.*—During the year, 5,659 cubic yards of stone, 817 cubic yards of earth, and an iron barge were removed from the head of the canal, completing the excavation at that point.

The cross-dam at the crest of the falls was extended 128 feet, and both wing and cross dams were thoroughly repaired.

No further appropriation is required for this work.

July 1, 1877, amount available	$82,650 6
July 1, 1878, amount expended during fiscal year	35,290 0
July 1, 1878, amount available	47,360 6

(See Appendix T 1.)

2. *Superintendence, management, and repair of the Louisville and Portland Canal.*—During the year, 4,772 boats have been passed through the canal; new guard-gates completed, and new winding-machinery, friction drums and chains have been put in; a new cistern has been built, and the fire department improved; an office for the superintendent has been completed; grading and sodding the lock-banks has been continued; the middle miter-sills were extensively repaired, and the work of improving the old locks by converting three chambers into two was commenced.

Tolls were reduced about one-fifth February 4, 1878, but, notwithstanding, the surplus of receipts over expenditures has continued to increase.

(See Appendix T 2.)

IMPROVEMENT OF OHIO RIVER; OF MONONGAHELA RIVER, WEST VIRGINIA AND PENNSYLVANIA; OF LITTLE KANAWHA AND GUYANDOTTE RIVERS, WEST VIRGINIA; OF BIG SANDY RIVER, KENTUCKY, AND CONSTRUCTION OF HARBOR AT OR NEAR CINCINNATI, TO PROTECT THE COMMERCE OF THE OHIO RIVER FROM FLOES OF ICE.

Officer in charge, Maj. William E. Merrill, Corps of Engineers, who has under his immediate orders Lieut. F. A. Mahan, Corps of Engineers.

In temporary charge of Lieutenant Mahan since March 25, 1878.

1. *Improvement of the Ohio River.*—The repairs on the old dike at White's Ripple, begun last season, were continued during the year, and the dike was extended 1,808 feet, at a height of 6½ feet above low water. The work of the past two seasons has stood well. It is proposed, during the low water season of this year, to extend the dike a farther distance of 1,500 feet, and to raise the transverse dam connecting it with the left bank of the river to the height of the dike.

The snag-boat E. A. Woodruff removed from the channel of the river during the season of 1877, 1,037 snags and 51 wrecks, the largest snag weighing 86 tons, the average weight being 8½ tons.

The dredges Ohio and Oswego have done the following dredging during the fiscal year:

	Cubic yards
Head of Raccoon Island	4,[illegible]
Foot of Gallipolis Island	34,851
Foot of Raccoon Island	2,145
Cullum's Ripple	23,825
Cumberland Dam	16,488
Total	81,879

And have also removed 8 wrecks and 12 snags.

The land required for the site of the movable dam at Davis Island has been obtained at a cost of $14,953, and it is proposed during the present season to commence the construction of the dam and also the improvement at the Grand Chain, for which special provision was made in the river and harbor act of June 18, 1878.

The dike at "The Trap" will be completed, that opposite the foot of Blennerhassett's Island repaired, and that at Evansville extended a farther distance of 500 feet.

The recommendation of the officer in charge that the wooden hull of the dredge Ohio be replaced by an iron hull is concurred in. He submits the following estimate for the fiscal year ending June 30, 1880:

To complete movable dam at Davis Island		$254,593 00
Dikes at Four Mile, Portland, Puppy Creek, and Caseyville		115,500 00
Removal of steamboat wrecks		20,000 00
New hull for dredge Ohio		26,000 00
Running expenses of snag-boat and dredges 8 months, at $6,000		48,000 00
Office expenses and contingencies		35,907 00
Total		500,000 00
July 1, 1877, amount available, including $6,924 due on outstanding liabilities	$181,443 36	
Amount appropriated by act approved June 18, 1878	300,000 00	
		$481,443 36
July 1, 1878, amount expended during fiscal year	91,336 31	
July 1, 1878, outstanding liabilities	391 72	
		91,728 03
July 1, 1878, amount available		389,715 33
Amount that can be profitably expended in fiscal year ending June 30, 1880		500,000 00

(See Appendixes U 1 and U 4.)

In connection with the question of the construction of the first movable dam across the Ohio below Pittsburgh, a report of a Board of Engineer Officers to examine and report upon the plan of a lock and gate proposed to be substituted by Major Merrill for the lock and gate heretofore approved will be found in Appendix U 1.

2. *Improvement of Monongahela River, West Virginia.*—Nothing was done upon this improvement during the fiscal year for want of funds.

The river and harbor act of June 18, 1878, contained an appropriation of $25,000, which will be applied to the completion of the lock at Hoard's Rocks.

The officer in charge submits an estimate of $115,000 to build a lock at Laurel Run.

July 1, 1877, amount available	$519 54	
Amount appropriated by act approved June 18, 1878	25,000 00	
		$25,519 54
July 1, 1878, amount expended during fiscal year	240 00	
July 1, 1878, outstanding liabilities	2,903 15	
		3,143 15
July 1, 1878, amount available		22,376 39

(See Appendix U 2.)

3. *Improvement of Little Kanawha River, West Virginia.*—The work of removing obstructions from the bed of this river was vigorously prosecuted and its condition was greatly improved. The Beaver and Nailor Bend Rocks were removed by contract, and the following work was done by hired labor:

2,282 cubic yards of brush and stone dikes were built.
4,114 cubic yards of stone were removed.
1,676 cubic yards of earth were removed.
3,128 leaning trees were cut down.
3,871 saplings were cut down.
2,927 snags were taken from the channel.
46 cords of drift were removed.
735 trees were trimmed.
12 acres of island bar were grubbed.

A portion of the appropriation of $18,000, made by the river and harbor act of June 18, 1878, will be applied to the removal of obstructions from the channel, and to the completion of observations necessary to the selection and proper location of site for a lock and dam, to be hereafter submitted. An estimate of $68,270 for completing the lock and dam is submitted by the officer in charge.

July 1, 1877, amount available, including $550 due on outstanding liabilities	$7,300 00	
Amount appropriated by act approved June 18, 1878	18,000 00	
		$25,300 00
July 1, 1878, amount expended during fiscal year		6,369 31
July 1, 1878, amount available		18,930 69
Amount that can be profitably expended in fiscal year ending June 30, 1880		68,270 00

(See Appendixes U 3 and U 4.)

4. *Improvement of Guyandotte River, West Virginia.*—An appropriation of $2,000 was made by the act of June 18, 1878, for the improvement of this river, and will be applied to the removal of snags, rocks, and other obstructions from its channel by means of hired labor and machinery.

Amount appropriated by act approved June 18, 1878	$2,000 00
July 1, 1878, amount available	2,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880	2,000 00

5. *Improvement of Big Sandy River from Catlettsburg, Kentucky, to the head of navigation.*—An appropriation of $12,000 was made by the act of June 18, 1878, for this improvement, which will be applied to the removal of obstructions to its navigation by means of hired labor and machinery.

Amount appropriated by act approved June 18, 1878	$12,000 00
July 1, 1878, amount available	12,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880	40,000 00

6. *Construction of harbor or harbors of refuge from ice-floes at or near Cincinnati, Ohio.*—The river and harbor act of June 18, 1878, contained an appropriation of $50,000 for the construction of this harbor. The importance of this work, and the large sum which must necessarily be expended in its construction, rendered it advisable that it be referred for consideration to a Board of Engineer Officers. When the report of the board is received it will be submitted to the Secretary of War, with request that it be transmitted to Congress.

Amount appropriated by act approved June 18, 1878	$50,000 00
July 1, 1878, amount available	50,000 00

(See Appendix U 5.)

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

To comply with provisions of the river and harbor act of June 18, 1878, Major Merrill has been charged with and is now engaged upon examinations and surveys at the following localities, the results of which will be duly submitted when received:

1. *The Muskingum River, Ohio, below the second dam, to ascertain its*

tability for an ice-harbor, for the protection of steamers and other craft he Ohio River.
The Allegheny River, up to the mouth of French Creek.
The Kiskiminetas and Conemaugh Rivers, Pennsylvania, from the h of the Kiskiminetas to the mouth of Stony Creek on the Conemaugh.
The Kentucky River and navigable tributaries, Kentucky.
The Licking River, Kentucky.

IMPROVEMENT OF WABASH RIVER, INDIANA.

ficer in charge, Maj. Jared A. Smith, Corps of Engineers.

e breach in the dam across New Harmony Cut-off, to which refer- was made in last annual report, has been closed and a strong bank ction placed on the island. Upon the completion of this a second h occurred in the old part of the dam, built by contract in 1876, h has been secured. It is proposed to place a substantial line of below the entire work to thoroughly secure it.

Grand Chain repairs have been made to the end dike.

Little Chain work has been delayed to obtain surveys of the main nel and of the cut-off in order to decide upon the best plan for the . Surveys have been made of the government lands at Grand ds and at the site of the dam, and also at New Harmony Cut-off, at Grand and Little Chains, and of about 10 miles of river below ast point.

e two United States dredge-boats belonging to the Ohio River im- ement were employed during parts of the months of April, May, June in removing snags and wrecks from the river.

ring the next fiscal year the improvements now in progress at New ony and Grand Chain will be completed, and, it is hoped, the now contemplated at Little Chain.

is proposed, also, to protect the banks at Grayville, Ill.; to close hutes at Turkey Island and other places; to remove snags, and to ne the channel, where necessary for the removal of bars, by means ng-dams or jetties.

e funds now available will accomplish much of this; but as the is extensive, a further appropriation will be required for its com- on.

, 1877, amount available	$85,679 61	
nt appropriated by act approved June 18, 1878	50,000 00	
		$135,679 61
, 1878, amount expended during fiscal year	37,701 90	
, 1878, outstanding liabilities	6,372 78	
		44,074 68
, 1878, amount available		91,604 93
nt that can be profitably expended in fiscal year ending June 30, 1880.		50,000 00

e Appendix V.)

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

comply with provisions of the river and harbor act of June 18, Major Smith has been charged with and is now engaged upon ex- ations and surveys at the following localities, the results of which e duly submitted when received:

The Kankakee River, Illinois and Indiana.
White River, Indiana, including the East Fork to the new bridge in e of construction near Bedford, and the West Fork to the town of Gos-

TRANSPORTATION ROUTES TO THE SEABOARD.

Part of third subdivision of the Mississippi transportation route to the seaboard.—In the appendix to the annual report of this office for the year 1875, and in Ex. Doc. No. 19, part 7, Senate, Forty-third Congress, second session, will be found a report from Maj. C. R. Suter, Corps of Engineers, presenting the results of his reconnaissance of the Mississippi River from Cairo to the mouth of Red River, made under the appropriation for surveys for transportation routes to the seaboard, in which he shows the number, location, extent, and character of the bars needing improvement in the low stage of the river, and submits a general project for their amelioration.

In continuation of his investigations Major Suter has submitted an additional report, in which he presents a new class of proofs as to the character and origin of these bars.

(See Appendix W 1.)

ALLUVIAL BASIN OF THE MISSISSIPPI.

In accordance with a resolution of the Commission of Engineers appointed under the act of June 22, 1874, to investigate and report a permanent plan for the reclamation of the alluvial basin of the Mississippi subject to inundation, specimens obtained from certain borings, made under its direction at the site of a proposed outlet to Lake Borgne, were transmitted to Prof. Eugene W. Hilgard, of Ann Arbor, Mich., for investigation, with instructions to transmit his report thereon to the Chief of Engineers.

This report is a valuable contribution to our knowledge of the formation of the delta of the Mississippi. Its practical importance in the further consideration of the question of a ship-canal is considerable, by adding reliable information as to the character of the material the canal would be excavated in and its capability to sustain the weight of suitable locks. It having been received too late for insertion in previous annual reports, it will be found herewith in Appendix W 2.

BRIDGING THE NAVIGABLE WATERS OF THE UNITED STATES.

1. *Bridging the Ohio River.*—In consequence of questions arising in the proposition to build a railroad bridge across the Ohio at or near Evansville, Ind., the Board of Engineer Officers, consisting of Majors Warren, Weitzel, and Merrill, which had been constituted in 1870, in compliance with the provisions of the river and harbor act of that year, for the examination of all bridges at that time built on the Ohio, was reconvened, and met at Evansville in November, but were unable to reach any conclusions for want of surveys at high water.

Some important modifications were suggested by the bridge interests in the requirements of existing laws, but surveys sufficiently thorough to enable the board to make a final report have not been furnished by the parties interested.

2. *Bridge at Beaver, Pennsylvania.*—To comply with the provisions of the act of December 17, 1872, authorizing the construction of bridges across the Ohio River, the Pittsburgh and Lake Erie Railroad Company submitted to the Secretary of War a plan for the construction of a bridge at Beaver, Pa. A Board of Engineer Officers was in consequence convened to examine this plan and the proposed location of the bridge. For the report of the board thereon, see Appendix XI.

3. *Bridge at Glasgow, Missouri.*—A Board of Engineer Officers was convened to consider and report upon the plan and location of a bridge proposed to be erected over the Missouri River at Glasgow, Mo., by the Kansas City, Saint Louis and Chicago Railroad Company, which had been submitted for the approval of the Secretary of War, in accordance with the act of Congress of March 13, 1878.

For the report of the board, see Appendix X 2.

4. *Bridge on the Mississippi, at Fort Snelling, Minnesota.*—The "act making appropriations for sundry civil expenses of the government for the fiscal year ending June thirtieth, eighteen hundred and seventy-nine, and for other purposes," approved June 20, 1878, made provision for the "construction and completion of a free wagon-bridge, with stone abutments, or stone and iron abutments, and iron superstructure, across the Mississippi River, at or near Fort Snelling," and appropriated the sum of $65,000 to aid in the same. The plans and specifications of the substructure were approved by the Secretary of War, and the officer of engineers stationed at Saint Paul was instructed to take such supervision of the bridge during its construction as will enable him to determine whether the approved plans and specifications are faithfully carried out.

5. *Report upon bridging the Mississippi River between Saint Louis, Missouri, and Saint Paul, Minnesota.*—The river and harbor act of June 23, 1866, made provision for examining and reporting upon the subject of constructing railroad-bridges across the Mississippi, between Saint Paul, Minn., and Saint Louis, Mo., upon such plans of construction as would offer the least impediment to the navigation of that river.

This subject was, at the time, assigned to Maj. G. K. Warren, Corps of Engineers, but his report thereon has been delayed from the pressure of other important duties. Since the date of the act there has been an almost continued increase of new and important data. The surveys which Major Warren had caused to be made did not include the bridges and changes made since 1870, but surveys having since been made of those bridges, and much additional information obtained, the report was completed and submitted to this office in March last, and transmitted to the Senate at its last session and printed in Senate Executive Document No. 69, Forty-fifth Congress, second session.

It is reprinted as Appendix X 3 of this report.

LAKE HARBORS AND RIVERS.

IMPROVEMENT OF HARBOR AT DULUTH, MINNESOTA, AND OF THE ENTRANCE TO SUPERIOR BAY, LAKE SUPERIOR.

Officer in charge, Maj. F. U. Farquhar, Corps of Engineers.

1. *Improvement of harbor at Duluth, Minnesota.*—A channel has been dredged by contract through the bar on the north side of the dike, and the dredging in the inside harbor continued.

During the present season it is proposed to continue the dredging and to repair the piers of the canal. To continue this work economically the officer in charge recommends an annual appropriation of $50,000 until the work is completed; also, that $10,000 additional should be made available for repairs of piers.

July 1, 1877, amount available	$16,683 59	
Amount appropriated by act approved June 18, 1878	30,000 00	
		$46,683 59
July 1, 1878, amount expended during fiscal year		13,049 55
July 1, 1878, amount available		33,634 04

Amount (estimated) required for completion of existing project		$184,293 18
Amount that can be profitably expended in fiscal year ending June 30, 1880:		
For dredging	$50,000 00	
For repair of piers	10,000 00	
		60,000 00

(See Appendix Y 1.)

2. *Improvement of natural entrance to the Bay of Superior.*—A brush and stone protection was built at "the opening," on Minnesota Point. The officer in charge recommends that the beach protection at the lower end of Minnesota Point be continued toward the light-house and some small repairs to the piers be made; also, that $10,000 be appropriated for such repairs to the superstructure of the piers as may be necessary.

July 1, 1877, amount available	$2,500 00	
Amount appropriated by act approved June 18, 1878	3,000 00	
		$5,500 00
July 1, 1878, amount expended during fiscal year		994 73
July 1, 1878, amount available		4,505 27
Amount (estimated) required for contingent repairs		10,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880		10,000 00

(See Appendix Y 2.)

HARBORS ON LAKE SUPERIOR (EXCEPT DULUTH AND SUPERIOR CITY), ON GREEN BAY, AND ON THE WESTERN SHORE OF LAKE MICHIGAN, NORTH OF MILWAUKEE, WISCONSIN.

Officer in charge, Maj. Henry M. Robert, Corps of Engineers.

1. *Improvement of Ontonagon Harbor, Michigan.*—Superstructure was finished over 10 cribs. One crib was refilled and replanked on the east pier, and refilling and riprapping were done on the west pier. Extensive repairs are now in progress, and 6 cribs will be placed in extension of the piers this season. It is proposed to continue the pier extension as fast as the appropriations will admit of. The piers are now each 1,300 feet long, the full length planned being 2,500 feet each.

This is an important work, being the only available harbor of refuge on a long stretch of coast.

July 1, 1877, amount available	$14,948 35	
Amount appropriated by act approved June 18, 1878	15,000 00	
		$29,948 35
July 1, 1878, amount expended during fiscal year		10,940 17
July 1, 1878, amount available		19,008 18
Amount (estimated) required for completion of existing project		178,170 00
Amount that can be profitably expended in fiscal year ending June 30, 1880		50,000 00

(See Appendix Z 1.)

2. *Improvement of Eagle Harbor, Michigan.*—The work of blasting a channel acoss the ledge of rock which obstructs the entrance to this harbor, commenced in 1875, was finished, and the broken rock removed by dredging. The work was done by hired labor at an actual cost of $10.83 per cubic yard in place, or $6.08 per yard in scows, after two contractors had attempted it and failed, though getting $40 and $58 per cubic yard, respectively.

Though the project contemplates a further expenditure of $178,362, the officer in charge does not think so large an outlay necessary to the safe use of the harbor, and there will be placed this season two guiding cribs to mark the channel, after which the only work done will be the

refilling and riprapping of these cribs, for which $2,000 will be required, the amount in which the last appropriation fell short of the officer's estimate.

July 1, 1877, amount available (of which $400 were not included in previous statements)	$13,988 77	
Amount appropriated by act approved June 18, 1878	8,000 00	
		$21,988 77
July 1, 1878, amount expended during fiscal year	11,566 66	
July 1, 1878, outstanding liabilities	25 00	
		11,591 66
July 1, 1878, amount available		10,397 11
Amount (estimated) required for completion of existing project		$178,362 36
Amount that can be profitably expended in fiscal year ending June 30, 1880.		2,000 00

(See Appendix Z 2.)

3. *Improvement of Marquette Harbor, Michigan.*—Slight repairs were made on the breakwater, and an examination was made to ascertain the amount of stone required for refilling, which is estimated at 1,000 cords. Of this quantity, about 400 cords will be put in during the present season, and the remainder, with such other repairs as are always needed to this exposed work, should be done during the fiscal year 1879–'80, for which the sum of $5,000 will be required. This breakwater was finished at a cost nearly $79,000 less than the estimate, and should be extended 400 linear feet, which would cost $68,000.

July 1, 1877, amount available	$2,490 90	
Amount appropriated by act approved June 18, 1878	2,000 00	
		$4,490 90
July , 1878, amount expended during fiscal year		1,532 59
July 1, 1878, amount available		2,958 31
Amount that can be profitably expended on repairs in fiscal year ending June 30, 1880		5,000 00

(See Appendix Z 3.)

4. *Improvement of Menomonee Harbor, Michigan and Wisconsin.*—Five new cribs were built and placed in extension of the piers, and 3,723.8 cubic yards of material were dredged from the bar, at a cost of ten cents per cubic yard; a resurvey of the channel was made, showing a 14-foot channel to the heads of the piers and for 1,000 yards up the river.

Three new cribs will be placed this season in extension of the piers and superstructure built over those placed last season. Further extension of the same work is proposed for the fiscal year 1879–'80.

July 1, 1877, amount available	$9,531 23	
Amount appropriated by act approved June 18, 1878	10,000 00	
		$19,531 23
July 1, 1878, amount expended during fiscal year		9,432 16
July 1, 1878, amount available		10,099 07
Amount (estimated) required for completion of existing project		69,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		40,000 00

(See Appendix Z 4.)

5. *Improvement of Green Bay Harbor, Wisconsin.*—Dredging on the line of previous work in the channel leading in from Green Bay was done to the amount of 39,282.5 cubic yards, which were removed at a cost of 12 cents per cubic yard. A resurvey of the channel 10,000 feet long was made through ice, to determine the proper location of future work. During the present season dredging in continuation of the improvement will be carried on as far as funds will permit. The same

work is proposed for the next fiscal year, with such repairs as the piers at Grassy Island may require.

The importance of this work is sufficiently indicated by its position at the mouth of Fox River, it really forming a part of the Fox and Wisconsin River improvement.

July 1, 1877, amount available	$6,144 43	
Amount appropriated by act approved June 18, 1878	5,000 00	
		$11,144 43
July 1, 1878, amount expended during fiscal year		6,085 60
July 1, 1878, amount available		5,058 83
Amount (estimated) required for completion of existing project		22,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880		12,000 00

(See Appendix Z 5.)

6. *Harbor of Refuge at entrance to Sturgeon Bay Canal, Wisconsin.*—The outer ends of the pier were refilled as far as the small sum available would permit and a set of soundings taken in the harbor. No work had been done since 1874. During the present season 14 cribs will be placed in extension of the piers and the old piers repaired. During the fiscal year 1879–'80 it is proposed to complete the pier extension and to commence dredging in the harbor.

The officer in charge refers to the vigorous prosecution of the canal work during the past year, and calls attention to certain defects in the construction of the canal and in the legislation of Congress granting the land-grant under which it is constructed, and to the relation which this work bears to the government harbor. He recommends that future appropriations be worded as the first were, the phraseology having been changed in the last appropriation bill; and expresses a belief that, although the canal may possibly be abandoned by the company, the government should finish the harbor at its entrance.

July 1, 1877, amount available	$401 21	
Amount appropriated by act approved June 18, 1878	30,000 00	
		$30,401 21
July 1, 1878, amount expended during fiscal year	253 04	
July 1, 1878, outstanding liabilities	7 00	
		260 04
July 1, 1878, amount available		30,141 17
Amount (estimated) required for completion of existing project		100,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880		60,000 00

(See Appendix Z 6.)

7. *Improvement of Ahuepee Harbor, Wisconsin.*—Superstructure over the 7 cribs of 1875, in progress at the date of the last annual report, was finished, and 1,100 linear feet of plank walk laid on the piers. The rock blasted from the river-bed was removed by the United States dredge, and 100 cords of the same was placed in the piers. The ice during the winter was not in condition to admit of work as expected, but the drilling and blasting were recommenced in June last, and will be prosecuted through the present season. Continuation of the same work is proposed during the fiscal year 1879–'80, with the repairs necessary for the preservation of the piers.

July 1, 1877, amount available	$6,997 05	
Amount appropriated by act approved June 18, 1878	8,000 00	
		$14,997 05
July 1, 1878, amount expended during fiscal year	5,486 11	
July 1, 1878, outstanding liabilities	253 80	
		5,739 91
July 1, 1878, amount available		9,257 14

Amount (estimated) required for completion of existing project	$79,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.	25,000 00

(See Appendix Z 7.)

8. *Improvement of Two Rivers Harbor, Wisconsin.*— Superstructure and plank walk over the 6 cribs of 1875, in progress at the date of the last annual report, was completed. Three hundred linear feet of pier was decked and soundings taken through the channel and in the vicinity of the bridge pier. During the present season sand-proof lining will be built on the pile piers and some dredging done between the piers. During the fiscal year 1879–'80 the operations contemplated are the further extension of the piers and dredging between them. This harbor has never been opened to the local commerce of the place, the work thereon not being sufficiently advanced. The private bridge pier has been used by vessels to the present time, and as accretions are rapidly forming around it, it becomes advisable to complete the harbor-work as soon as possible.

July 1, 1877, amount available	$4,969 12	
Amount appropriated by act approved June 18, 1878	10,000 00	
		$14,969 12
July 1, 1878, amount expended during fiscal year		4,951 24
July 1, 1878, amount available		10,017 88
Amount (estimated) required for completion of existing project		145,588 80
Amount that can be profitably expended in fiscal year ending June 30, 1880.		40,000 00

(See Appendix Z 8.)

9. *Improvement of Manitowoc Harbor, Wisconsin.*—The repair-work in progress at the date of the last annual report was completed and a series of soundings taken through the channel. During the present season four new cribs will be placed, the piers will be refilled, and repairs made as necessary. During the fiscal year 1879–'80 it is proposed to extend the piers to 18 feet water, and do such dredging as may be necessary. If the whole amount estimated for that year be appropriated, this harbor can be finished within the estimated cost, notwithstanding that the small appropriations have necessitated a good deal of repair-work. This port, being the most frequently sought in stormy weather on the northwestern shore of Lake Michigan, should be completed at as early a day as possible.

July 1, 1877, amount available	$2,131 69	
Amount appropriated by act approved June 18, 1878	15,000 00	
		$17,131 69
July 1, 1878, amount expended during fiscal year		2,062 40
July 1, 1878, amount available		15,069 29
Amount (estimated) required for completion of existing project		21,682 54
Amount that can be profitably expended in fiscal year ending June 30, 1880.		21,682 54

(See Appendix Z 9.)

10. *Improvement of Sheboygan Harbor, Wisconsin.*—The cost of this harbor has so far exceeded the estimate by over $8,000, but the work since 1875 has been almost wholly repairs to the piers. These repairs were continued from November to May, and will be prosecuted during the present season and during the fiscal year 1879–'80. It is estimated that they will cost $12,000 to complete, of which $4,000 was appropriated this year.

It became necessary to dredge out the channel this last spring, an unusually heavy gale having moved a large quantity of beach sand into it. The work was done by the United States dredge, which was moved for

this purpose from Port Washington, the city of Sheboygan paying all expenses of towing. Cubic yards of material removed, 7,117.

July 1, 1877, amount available	$3,049 24	
Amount appropriated by act approved June 18, 1878	4,000 00	
		$7,049 24
July 1, 1878, amount expended during fiscal year		3,037 66
July 1, 1878, amount available		4,011 58
Amount (estimated) required for completion of repairs and dredging		10,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		10,000 00

(See Appendix Z 10.)

11. *Improvement of Port Washington Harbor, Wisconsin.*—The excavation of the north basin was commenced by the United States dredge in accordance with the modified plan approved June 7, 1877. Forty-five thousand two hundred and thirty-two cubic yards were removed to November 30, at an expense of $\$0.12\frac{35}{100}$ per cubic yard, against $\$0.34\frac{3}{10}$ to $\$0.56\frac{1}{2}$ per cubic yard paid by contract in previous years at this harbor. Thirty-two hundred and sixty-two cubic yards were removed from the channel and repairs made on the north pier. Dredging was recommenced June 17 and will be continued during the present season, and will be renewed with the funds appropriated for the fiscal year 1879–'80.

July 1, 1877, amount available	$7,545 18	
Amount appropriated by act approved June 18, 1878	5,000 00	
		$12,545 18
July 1, 1878, amount expended during fiscal year	7,113 83	
July 1, 1878, outstanding liabilities	146 53	
		7,260 36
July 1, 1878, amount available		5,284 82
Amount (estimated) required for completion of existing project		53,527 17
Amount that can be profitably expended in fiscal year ending June 30, 1880.		25,000 00

(See Appendix Z 11.)

IMPROVEMENT OF HARBORS OF MILWAUKEE, RACINE, AND KENOSHA, LAKE MICHIGAN, AND OF FOX AND WISCONSIN RIVERS.

Officer in charge, Maj. D. C. Houston, Corps of Engineers, with Lieut. F. A. Hinman, Corps of Engineers, under his immediate orders.

1. *Improvement of Milwaukee Harbor, Wisconsin.*—The rebuilding of the superstructure of the south pier for a distance of 1,130 feet was completed; the stone superstructure on the north pier extended 98 feet; 266 feet of pile protection put in, and some repairs made to the timber work at the inner end of both piers.

The appropriation of June 18, 1878, of $15,000 will be applied toward completing the stone superstructure of the north pier.

July 1, 1877, amount available	$18,027 20	
Amount appropriated by act approved June 18, 1878	15,000 00	
		$33,027 20
July 1, 1878, amount expended during fiscal year		15,937 78
July 1, 1878, amount available		17,089 42
Amount (estimated) required for completion of existing project		15,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		15,000 00

(See Appendix A A 1.)

2. *Improvement of Racine Harbor, Wisconsin.*—During the year the rebuilding of the old superstructure of the north pier for a distance of about 600 feet was completed.

appropriation of June 18, 1878, will be applied to extending the pier 50 feet and dredging between the piers.

1877, amount available	$6,143 32	
t appropriated by act approved June 18, 1878	10,000 00	
		$16,143 32
1878, amount expended during fiscal year		5,278 23
1878, amount available		10,865 09
(estimated) required for completion of existing project		20,000 00
that can be profitably expended in fiscal year ending June 30, 1880.		20,000 00

Appendix A A 2.)

mprovement of Kenosha Harbor, Wisconsin.—During the year 10,000 cubic yards of material were dredged from the harbor. appropriation of June 18, 1878, will be applied to extending the pier 50 feet and repairs of old work.

1877, amount available	$4,071 25	
appropriated by act approved June 18, 1878	8,000 00	
		$12,071 25
1878, amount expended during fiscal year		3,133 00
1878, amount available		8,938 25
(estimated) required for completion of existing project		72,000 00
that can be profitably expended in fiscal year ending June 30, 1880.		20,000 00

Appendix A A 3.)

mprovement of the Fox and Wisconsin Rivers.—The improvement e rivers is being carried on in accordance with the plan heretofore d, and the results are given in detail in the accompanying reports appendix.

igation is now open on the Fox River from Green Bay to Portage

1877, amount available	$145,308 01	
ceived and deposited to credit of appropriation	2,312 06	
appropriated by act approved June 18, 1878	250,000 00	
		$397,620 07
1878, amount expended during fiscal year	108,750 38	
1878, outstanding liabilities	5,141 92	
		113,892 30
1878, amount available		283,727 77
(estimated) required for completion of existing project		2,725,663 00
that can be profitably expended in fiscal year ending June 30, 1880.		750,000 00

Appendix A A 4.)

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

omply with provisions of the river and harbor act of June 18, 1878, Houston has been charged with and is now engaged upon an ex- ion and survey of *Wolf River, from Lake Boygan to Red River, sin*, the result of which will be duly submitted when received.

VEMENT OF HARBORS OF CHICAGO, CALUMET, MICHIGAN CITY, NEW BUFFALO, LAKE MICHIGAN, AND OF ILLINOIS RIVER.

er in charge, Capt. G. J. Lydecker, Corps of Engineers.

provement of Chicago Harbor, Illinois.—Operations were restricted t repairs of existing works, there being no money for doing any rk.

The amount appropriated by the act approved June 18, 1878, it is j
posed to expend as follows:

For breakwater construction	$55
For dredging channel through outer harbor	15

For the fiscal year ending June 30, 1880, an appropriation of $125,
is recommended by the officer in charge, to be applied as follows: $100,
for continuation of breakwater; $20,000 for dredging in outer harl
$5,000 for repairs and preservation of old piers and breakwater.

July 1, 1877, amount available	$3,669 48	
Amount appropriated by act approved June 18, 1878	75,000 00	
		$78,66
July 1, 1878, amount expended during fiscal year		3,36
July 1, 1878, amount available		75,30
Amount (estimated) required for completion of existing project		250,00
Amount that can be profitably expended in fiscal year ending June 30, 1880		125,00

(See Appendix B B 1.)

2. *Improvement of Calumet Harbor, Illinois.*—Dredging chan
through bar at harbor entrance was in progress at the beginning of
year, and continued during July; this part of the work was then
continued, a channel 100 feet wide with a depth of 15 feet having b
made.

Three cribs, for the extension of the north pier, were built and su
during the months of July and August.

It is proposed to apply the present appropriation to extending
north pier 200 feet farther, and to restoring the channel through
outer bar.

This channel can only be maintained and the entrance kept o
(without annual dredging) after the pier shall have been extended i
at least 18 feet of water; when this is accomplished, the full width
channel can be dredged, and its depth can be maintained.

For this purpose an appropriation of $40,000 is recommended by
officer in charge for the year ending June 30, 1880, to be applied
follows: $30,000 for pier construction; $10,000 for dredging.

July 1, 1877, amount available	$12,851 24	
Amount appropriated by act approved June 18, 1878	15,000 00	
		$27,851
July 1, 1878, amount expended during fiscal year		11,821
July 1, 1878, amount available		16,030
Amount (estimated) required for completion of existing project		40,000
Amount that can be profitably expended in fiscal year ending June 30, 1880		40,000

(See Appendix B B 2.)

3. *Improvement of Michigan City Harbor, Indiana.*—The work of
pairing damage done to the unfinished cribs of the breakwater by sto
during the winter of 1876–'77 was finished about the close of July.
superstructure, limited by reason of lack of funds to a height of f
courses only, was subsequently placed. In October and Novembe
series of violent gales occasioned great damage to the work, to rep
which an allotment of $2,500 was made from the appropriation for "
pair, preservation, extension, and completion of river and harbor wor

The extreme violence of the sea at this locality calls for a superstr
ture of unusual height, and the entire work should be completed duri
the summer and early fall months. There is urgent need of making t
appropriation for the year ending June 30, 1880, sufficient to compl

the breakwater, and do some considerable dredging in the outer harbor to render it available. For this purpose the appropriation should not be less than $50,000, all of which should be applied to completing the outer harbor.

July 1, 1877, amount available	$8,990 11	
Allotment from appropriation for repairing, preservation, extension, and completion of river and harbor work	2,500 00	
Amount appropriated by act approved June 18, 1878	75,000 00	
		$86,490 11
July 1, 1878, amount expended during fiscal year		11,490 11
July 1, 1878, amount available		75,000 00
Amount (estimated) required for completion of existing project		50,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		50,000 00

(See Appendix B B 3.)

4. *Improvement of New Buffalo Harbor, Michigan.*—There was no work done here during the year. None is contemplated for the ensuing year. There has been no appropriation for this improvement since 1872, and none is now recommended.

July 1, 1877, amount available	$5,013 44
July 1, 1878, amount expended during fiscal year	13 44
July 1, 1878, amount available	5,000 00

(See Appendix B B 4.)

5. *Improvement of Illinois River.*—Work of improving the river by dredging channels through the various bars has been carried on as in previous years.

The officer in charge of the improvement recommends that the work in future be done by machinery owned and operated by the government, instead of by contract as heretofore, believing there will result a great saving in money and in time also.

If this project be approved, an appropriation of $75,000 is recommended by him for the fiscal year ending June 30, 1880. If the work be continued by *contract*, this amount should be increased to $100,000.

July 1, 1877, amount available	$27,624 14	
Amount appropriated by act approved June 18, 1878	75,000 00	
		$102,624 14
July 1, 1878, amount expended during fiscal year		24,490 72
July 1, 1878, amount available		78,133 42
Amount that can be profitably expended in fiscal year ending June 30, 1880.		75,000 00

(See Appendix B B 5.)

IMPROVEMENT OF HARBORS ON THE EASTERN SHORE OF LAKE MICHIGAN.

Officer in charge, Maj. S. M. Mansfield, Corps of Engineers.

1. *Improvement of Charlevoix Harbor, Michigan.*—Congress appropriated $10,000 in the act of August 14, 1876, to begin improvements here, and it was expended during the season of 1877 in widening and deepening the channel near the lake and constructing a south pier of crib and brush work (349 feet in length) for its protection against the drift of sand along the beach. The old pier (472 feet in length) was repaired and made serviceable as a north pier.

This spring a narrow bar at the shore-line, with but 8 feet water on it, obstructs the navigation of an otherwise fair channel.

The appropriation of $12,000 of June 18, 1878, will be expended in extending the piers into deeper water.

The officer in charge suggests that in further continuance of this work of improvement, $30,000 could be profitably expended in the next fiscal year in pier extension and channel widening and deepening.

July 1, 1877, amount available	$5,244 24	
Amount appropriated by act approved June 18, 1878	12,000 00	
		$17,244 24
July 1, 1878, amount expended during fiscal year		5,167 22
July 1, 1878, amount available		12,077 02
Amount (estimated) required for completion of existing project		164,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		30,000 00

(See Appendix C C 1.)

2. *Improvement of Frankfort Harbor, Michigan.*—One crib (50 feet in length) was added to the south pier during the season of 1877, and about 300 feet in length of this pier was raised to the proper level above the water, while both piers were refilled with stone, and some minor repairs were made to the revetment.

A bar, with but 9½ feet of water on it, covers the approach to the harbor this spring, while the channel between the piers has at least 11 feet water.

The appropriation of $8,800, of June 18, 1878, will be expended in extending both piers 50 feet into the lake.

The balance of the original estimate, $13,200, can be profitably expended in the fiscal year ending June 30, 1880, in a further extension of the piers.

July 1, 1877, amount available	$3,450 31	
Amount appropriated by act approved June 18, 1878	8,800 00	
		$12,250 31
July 1, 1878, amount expended during fiscal year		3,373 29
July 1, 1878, amount available		8,877 02
Amount (estimated) required for completion of existing project		13,200 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		13,200 00

(See Appendix C C 2.)

3. *Improvement of Manistee Harbor, Michigan.*—The point of sand in the bend of the river, on north side, was dredged away during the season, and the exposed bank faced with a pile-revetment for a length of 420 feet, and 32 cords of stone were put into the piers as ballast.

A bar, with but 8 feet water over it, obstructed the entrance to the harbor this spring. At the solicitation of certain lumber manufacturers of Manistee, a channel was dredged through it, with the small balance of funds remaining over, leaving now a channel of good width and with a depth of 14 feet.

The appropriation of $15,000, of June 18, 1878, wil lbe expended this season in extending both piers 100 feet.

The piers require further extension. The balance of the original estimates made therefor is $61,771, of which sum $30,000 could be very profitably expended in the next fiscal year.

July 1, 1877, amount available	$7,169 79	
Amount appropriated by act approved June 18, 1878	15,000 00	
		$22,169 79
July 1, 1878, amount expended during fiscal year		6,452 53
July 1, 1878, amount available		15,717 26
Amount (estimated) required for completion of existing project		61,771 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		30,000 00

(See Appendix C C 3.)

4. *Improvement of Ludington Harbor, Michigan.*—During the season the south pier was extended 100 feet, and repairs to both piers were made in the way of releveling and reballasting. In the fall the United States dredge removed 6000 yards, of sand from the channel, leaving an available water-way of 13 feet. There is full 12 feet water here now.

The appropriation of $15,000 of June 18, 1878, will be expended this season in extending the north pier 100 feet and the south pier 50 feet.

Recommendations for pier extension have heretofore been made, and are renewed. The unappropriated balance of $11,000 can be profitably expended during the year ending June 30, 1880.

July 1, 1877, amount available	$4,043 03	
Amount appropriated by act approved June 18, 1878	15,000 00	
		$19,043 03
July 1, 1878, amount expended during fiscal year		3,325 77
July 1, 1878, amount available		15,717 26
Amount (estimated) required for completion of existing project		11,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		11,000 00

(See Appendix C C 4.)

5. *Improvement of Pentwater Harbor, Michigan.*—During the season the north pile-revetment was extended 552 feet in an easterly direction, and 14,900 cubic yards were dredged from the bank and channel, leaving a water-way of 12 feet through the middle. The pier-heads were reballasted and some slight repairs made.

The shoalest water this spring is 9 feet for a short distance near the shore-line.

The appropriation of $10,000 of June 18, 1878, will be expended this season in building 600 feet of pile-revetment, extending the north pier in an easterly direction.

The recommendations and estimates of previous years are renewed. The unappropriated balance of $29,200 can be profitably expended in the fiscal year ending June 30, 1880, in completing revetment and pier extension.

July 1, 1877, amount available	$3,871 30	
Amount appropriated by act approved June 18, 1878	10,000 00	
		$13,871 30
July 1, 1878, amount expended during fiscal year		3,126 55
July 1, 1878, amount available		10,744 75
Amount (estimated) required for completion of existing project		29,200 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		29,200 00

(See Appendix C C 5.)

6. *Improvement of White River Harbor, Michigan.*—In September and October the United States dredge removed 8,580 cubic yards of material from the channel, leaving an available water-way of 11 feet.

Two hundred feet of pier-work, westward of the shore-line, being the most defective portion, received a new filling of brush mattresses, edgings, and stone, and pier-heads were reballasted. The available depth of water this spring in the channel and on the bar is 10 feet.

The appropriation of $12,000 of June 18, 1878, will be expended this season in extending the south pier 50 feet and overhauling and refilling the pile piers with brush, edgings, and stone.

In continuance of improvements here, as suggested in previous reports (pier extension), the unappropriated balance of the estimate of 1873, $19,891.56, together with the estimate of $5,000 for dredging, or $24,891.56, can be profitably expended in the next fiscal year.

July 1, 1877, amount available	$2,929 67	
Amount appropriated by act approved June 18, 1878	12,000 00	
		$14,929 67
July 1, 1878, amount expended during fiscal year		2,802 02
July 1, 1878, amount available		12,127 65
Amount (estimated) required for completion of existing project		24,891 56
Amount that can be profitably expended in fiscal year ending June 30, 1880.		24,891 56

(See Appendix C C 6.)

7. *Improvement of Muskegon Harbor, Michigan.*—During the year the south pier has been extended 100 feet. Several openings and defective places in both piers were repaired, and an 88-foot gap in the old slab pier was refilled. The available depth of water between the piers this spring is 14 feet, with no bar outside.

No appropriation was required for the fiscal year 1878–'79, and none made. A balance of $4,393.46 of former appropriation will be applied this season to reconstructing the superstructure over outer two cribs of north pier, closing intervals, refilling superstructure, and placing fenders around pier-heads.

Of the original estimate for this work there remains unappropriated a balance of $8,898.04, which can be profitably expended in extending the north pier 50 feet and making repairs during the next fiscal year.

July 1, 1877, amount available	$9,281 48
July 1, 1878, amount expended during fiscal year	4,888 02
July 1, 1878, amount available	4,393 46
Amount (estimated) required for completion of existing project	8,898 04
Amount that can be profitably expended in fiscal year ending June 30, 1880.	8,898 04

(See Appendix C C 7.)

8. *Improvement of Grand Haven Harbor, Michigan.*—During the year the north pier was extended 150 feet. In the fall a bar appeared off the entrance, which gradually increased till the necessity for its removal became so great that, for want of funds for the purpose, it was dredged away by the steamboat company, and a channel left about 200 feet wide, with 14½ feet water. The deepest water on the bar this spring was 15½ feet.

The appropriation of $15,000 of June 18, 1878, will be expended this season in extending the north pier 150 feet.

There remains unappropriated of the original estimate for the completion of the work at this harbor $29,148.96, which amount can be profitably expended in the fiscal year ending June 30, 1880.

July 1, 1877, amount available	$3,003 39	
Amount appropriated by act approved June 18, 1878	15,000 00	
		$18,003 39
July 1, 1878, amount expended during fiscal year		3,003 18
July 1, 1878, amount available		15,000 21
Amount (estimated) required for completion of existing project		29,148 96
Amount that can be profitably expended in fiscal year ending June 30, 1880.		29,148 96

(See Appendix C C 8.)

9. *Improvement of Black Lake Harbor, Michigan.*—During the year the south pier was extended 50 feet, 700 running feet of revetment overhauled and refilled in a manner to effectually stop the action of the sea

through it, and 35,775 cubic yards of sand, &c., were dredged from the channel-way.

In the fall there was an available water-way of 9 feet in the channel. This spring we find the channel shoaled in one place to 8 feet.

The appropriation of $10,000 of June 18, 1878, will be expended this season in extending the south pier 50 feet and the north pier 100 feet.

The recommendations heretofore made are renewed, and the unappropriated balance of $22,000 can be profitably expended in extending the piers during the fiscal year ending June 30, 1880.

July 1, 1877, amount available	$10,482 15	
Amount appropriated by act approved June 18, 1878	10,000 00	
		$20,482 15
July 1, 1878, amount expended during fiscal year		9,779 57
July 1, 1878, amount available		10,702 58
Amount (estimated) required for completion of existing project		22,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		22,000 00

(See Appendix C C 9.)

10. *Improvement of Saugatuck Harbor, Michigan.*—The only work done here during the year was the lightering of some stone from the south to the north pier for ballast at the outer end.

In the fall the channel shoaled from the north pier-head, leaving a narrow passage of 50 feet.

The appropriation of $2,500 of June 18, 1878, will be expended in filling with brush and stone the north pier for a length of 300 feet.

The depth of water is from 9 to 10 feet in the channel and out to deep water.

The unappropriated balance of the existing estimate for the completion of the work is $35,958.74. An appropriation of $10,000 is recommended by the officer in charge for pier extension in the next fiscal year.

July 1, 1877, amount available	$427 21	
Amount appropriated by act approved June 18, 1878	2,500 00	
		$2,927 21
July 1, 1878, amount expended during fiscal year	412 13	
July 1, 1878, outstanding liabilities	9 75	
		421 88
July 1, 1878, amount available		2,505 33
Amount (estimated) required for completion of existing project		35,958 74
Amount that can be profitably expended in fiscal year ending June 30, 1880.		10,000 00

(See Appendix C C 10.)

11. *Improvement of South Haven Harbor, Michigan.*—The work in hand at the end of the last fiscal year was continued and progressed satisfactorily until funds were exhausted.

At the end of the season there was a depth of 9 feet in the channel from entrance to warehouse. This spring the channel has shoaled to about 7½ feet for a short distance between the piers.

The appropriation of $12,000 of June 18, 1878, will be expended this season in dredging and building 450 feet of revetment on north side.

The balance remaining unappropriated, $60,000, is considered sufficient to complete all permanent improvements at this harbor under the present project. The sum of $25,000 can be profitably expended during the fiscal year ending June 30, 1880, in extending the piers and deepening the channel.

July 1, 1877, amount available	$3,914 92	
Amount appropriated by act approved June 18, 1878	12,000 00	
		$15,914 92
July 1, 1878, amount expended during fiscal year		3,814 90
July 1, 1878, amount available		12,100 02
Amount (estimated) required for completion of existing project		60,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		25,000 00

(See Appendix C C 11.)

12. *Improvement of Saint Joseph Harbor, Michigan.*—One crib (50 feet) was added to the north pier, and a portion of this pier leveled up and refilled during the year.

The water in the channel holds to a good depth, there being from 15 to 17 feet in the best approaches.

The appropriation of $12,000 of June 18, 1878, will be expended this season in extending the north pier 100 feet, and making some necessary repairs. The existing project looks to an extension of this pier. Of the original estimate there remains still to be appropriated the sum of $4,216.71, which can be profitably expended in the fiscal year ending June 30, 1880, and in addition, $15,000 will be required for the improvement in the river at the mouth of the canal leading to Benton Harbor.

July 1, 1877, amount available	$7,007 30	
Amount appropriated by act approved June 18, 1878	12,000 00	
		$19,007 30
July 1, 1878, amount expended during fiscal year		4,947 52
July 1, 1878, amount available		14,059 78
Amount (estimated) required for completion of existing project		19,216 71
Amount that can be profitably expended in fiscal year ending June 30, 1880.		19,216 71

(See Appendix C C 12.)

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

To comply with provisions of the river and harbor act of June 18, 1878, Major Mansfield has been charged with and is now engaged upon an examination and survey of *Portage Lake, Manistee County, Michigan, with a view to its adaptability as a harbor of refuge*, the result of which will be duly submitted when received.

IMPROVEMENT OF SAINT MARY'S FALLS CANAL—CONSTRUCTION OF HARBOR OF REFUGE ON LAKE HURON—IMPROVEMENT OF DETROIT RIVER.

Officer in charge, Maj. G. Weitzel, Corps of Engineers, with Capt. Alexander Mackenzie, Corps of Engineers, under his immediate orders.

During the temporary absence of Major Weitzel, from May 15, 1878, these works were under the charge of Captain Mackenzie.

1. *Improvement of Saint Mary's Falls Canal, Michigan.*—During the year, 128,512 cubic feet of cut-stone have been delivered; 18,683.46 cubic yards of masonry laid in the walls; 6,853 cubic yards of earth have been placed behind the new lock walls; 44,727 cubic yards of earth were removed in enlarging the canal, and 1,070 linear feet of crib-work have been placed; 18,351 barrels of cement have been received. A shoal near the upper entrance to the canal has been dredged to a depth of 13 feet.

For an economical and rapid prosecution of the work, the officer in

charge is of the opinion that $395,000 should be appropriated for the fiscal year ending June 30, 1880.

July 1, 1877, amount available	$419,014 09	
Amount appropriated by act approved June 18, 1878	175,000 00	
		$594,014 09
July 1, 1878, amount expended during fiscal year		249,345 47
July 1, 1878, amount available		344,668 62
Amount (estimated) required for completion of existing project		395,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		395,000 00

(See Appendix D D 1.)

2. *Construction of harbor of refuge, Lake Huron, Michigan.*—During the past year the superstructure was built over 13 cribs sunk in 1876, and 5 cribs, 65 by 38 feet, were built and sunk. There are now in place 4,230 linear feet of crib-work, and 3,905 linear feet, or nearly one-half of the breakwater, are completed.

The wreck of the schooner City of Buffalo and several dangerous bowlders have been removed from the harbor. During the season 637 boats made use of the harbor of refuge.

It is estimated that $230,000 is required to complete this work, and for the sake of economy it is recommended by the officer in charge that this sum be appropriated for the fiscal year ending June 30, 1880.

July 1, 1877, amount available	$76,325 01	
Amount appropriated by act approved June 18, 1878	100,000 00	
		$176,325 01
July 1, 1878, amount expended during fiscal year		72,659 66
July 1, 1878, amount available		103,665 35
Amount (estimated) required for completion of existing project		230,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		230,000 00

(See Appendix D D 2.)

3. *Improvement of Detroit River.*—The funds for this improvement having been entirely exhausted, nothing was done during the year.

It is estimated by the officer in charge that $250,000 will be required to complete this work, and it is recommended that the sum of $100,000 be appropriated for the fiscal year ending June 30, 1880.

Amount appropriated by act approved June 18, 1878	$100,000 00
July 1, 1878, amount available	100,000 00
Amount (estimated) required for completion of existing project	250,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.	100,000 00

(See Appendix D D 3.)

REPAIR AND PRESERVATION OF SAINT CLAIR FLATS CANAL—IMPROVEMENT OF SAGINAW RIVER AND OF CERTAIN HARBORS ON LAKE HURON.

Officer in charge, Maj. Franklin Harwood, Corps of Engineers.

1. *Saint Clair Flats Canal.*—The damage to the canal banks, mentioned in last report, was repaired during the summer and fall of 1877 at a total cost of $3,603.55. The canal is now in good condition. Minor repairs are needed at the pier-heads, for which estimate is made. Prosecutions against trespassers on the canal banks have resulted in the vindication of the law, and securing respect for the authority of the custodian.

July 1, 1877, amount available	$5,883 98	
Amount appropriated by act approved June 18, 1878	5,000 00	
		$10,883 98
July 1, 1878, amount expended during fiscal year	5,883 98	
July 1, 1878, outstanding liabilities	775 00	
		6,658 98
July 1, 1878, amount available		4,225 00
Amount (estimated) required for repairs, &c		3,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		3,000 00

(See Appendix E E 1.)

2. *Improvement of Saint Clair River at the mouth of Black River, Michigan.*—No work has been done during the fiscal year for lack of appropriation. The appropriation for 1878–'79 will be used in ascertaining the present condition of the shoal, and removing it completely, if possible. But if it be found inadequate, the balance unexpended will be reserved to be added to a future appropriation for a complete removal of the shoal. In this case no work will be attempted until a sufficient sum is provided for the entire completion of the existing project.

Amount appropriated by act approved June 18, 1878	$1,500 00
July 1, 1878, amount available	1,500 00
Amount (estimated) required for completion of existing project	1,500 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.	1,500 00

(See Appendix E E 2.)

3. *Improvement of Au Sable River Harbor, Michigan.*—No appropriation is asked for until jurisdiction over the river and harbor banks for purposes of improvement can be secured by the United States.

July 1, 1877, amount available	$2,113 49
July 1, 1878, amount expended during fiscal year	1,493 38
July 1, 1878, amount available	620 11

(See Appendix E E 3.)

4. *Improvement of Saginaw River, Michigan.*—The project of last year, as stated in the annual report, was fulfilled and the Carollton Bar revetment connected with the main land at both extremities. A portion of the work, still incomplete, will be finished during the present working season. A section of the revetment, burnt by fire, caught from the sparks of a passing steamer, will be renewed, and the revetment sheathed on its river face to prevent the recurrence of a like disaster. It is expected to complete the Carrollton revetment and channel 100 feet wide and 10 feet deep during the present working season.

July 1, 1877, amount available	$10,402 01	
Amount appropriated by act approved June 18, 1878	25,000 00	
		$35,402 01
July 1, 1878, amount expended during fiscal year		10,402 01
July 1, 1878, amount available		25,000 00
Amount (estimated) required for completion of existing project		25,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		25,000 00

(See Appendix E E 4.)

5. *Improvement of Alpena Harbor, Michigan.*—The work as projected last year was completed by contract labor, and the harbor is now in good condition. No further appropriation is required.

July 1, 1877, amount available	$4,500 00
July 1, 1878, amount expended during fiscal year	3,935 36
July 1, 1878, amount available	564 64

(See Appendix E E 5.)

6. *Improvement of Cheboygan Harbor, Michigan.*—By use of two dredges, hired under contract, the channel of entrance was widened from 150 to 175 feet, and a width of over 200 feet attained abreast of the steamboat landings, all with a clear depth of 13 feet of water, low stage. Propellers, not exceeding 225 feet in length and 12½ feet in draft, can now freely enter, turn, and depart.

The $8,000 appropriated by act approved June 18, 1878, will be expended under contract during the present working season in widening the exterior channel to 175 feet. Twelve thousand dollars in addition is asked for to complete the project.

July 1, 1877, amount available	$9,920 77	
Amount appropriated by act approved June 18, 1878	8,000 00	
		$17,920 77
July 1, 1878, amount expended during fiscal year		9,920 77
July 1, 1878, amount available		8,000 00
Amount (estimated) required for completion of existing project		12,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		12,000 00

(See Appendix E E 6.)

IMPROVEMENT OF HARBORS ON LAKE ERIE, WEST OF CLEVELAND.

Officer in charge, Lieut. Col. N. Michler, Corps of Engineers.

1. *Improvement of Monroe Harbor, Michigan.*—Work was continued during the first three months of the fiscal year, until the appropriation became exhausted. Along the south side of the canal 1,425 linear feet of revetment, and on the north side 100 feet, were renewed. There were also completed 380 feet of extension of the revetment on the north side. Some slight repairs to the crib-work of the piers were made. There still remains to be renewed about 1,500 feet of revetment on the sides of the United States Ship-canal, and 1,750 of the Monroe City Canal.

July 1, 1877, amount available	$4,492 44	
Amount appropriated by act approved June 18, 1878	2,500 00	
		$6,992 44
July 1, 1878, amount expended during fiscal year	4,481 74	
July 1, 1878, outstanding liabilities	10 70	
		4,492 44
July 1, 1878, amount available		2,500 00
Amount (estimated) required for completion of existing project		7,500 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		7,500 00

(See Appendix F F 1.)

2. *Improvement of Toledo Harbor, Ohio.*—The work of dredging the natural channel through Maumee Bay, between Point Presqu'ile at the mouth of the Maumee River, to the curve of 15 feet in the lake, was continued during the fiscal year in accordance with the plan recommended by the Board of Engineers, and adopted in January, 1873. The dredging was principally confined to widening and deepening the inner, middle, and outer ranges, the southwest and south reaches, and the outer reach or outer bar. The elbows or curves were also widened and deepened. The two contracts by which the work was executed expired during the year, the appropriation having been expended; the aggregate number of cubic yards displaced under them was 345,858, at a cost, including dredging and all incidental expenses, $59,623.85. The projected dimensions of the channel are 250 feet in width at top, 200 at bottom, and 15

feet in depth at average low-water mark. The work of dredging w be continued during the present fiscal year.

July 1, 1877, amount available	$50,769 35	
Amount appropriated by act approved June 18, 1878	50,000 00	
		$100,769
July 1, 1878, amount expended during fiscal year		50,393
July 1, 1878, amount available		50,376
Amount (estimated) required for completion of existing project		30,000
Amount that can be profitably expended in fiscal year ending June 30, 1880.		30,000

(See Appendix F F 2.)

3. *Improvement of Port Clinton Harbor, Ohio.*—During the months July and August of the fiscal year the construction of the east rev ment to the canal or artificial harbor, which extends from the mouth Portage River, was continued until the appropriation was expend In all 550 linear feet of revetment were built, and 355 additional are s required. Beyond the bulkheads at the ends of the revetments t parallel piers of crib-work will be built out into the lake for an aver length of 1,200 feet each, until the curve of 10 feet is reached. A nar channel-way will be partially dredged between the piers throughout entire length, when it is expected that the strong current of the ri will open a channel of suitable dimensions to answer the wants of c merce.

July 1, 1877, amount available	$4,929 93	
Amount appropriated by act approved June 18, 1878	10,000 00	
		$14,92
July 1, 1878, amount expended during fiscal year	4,913 83	
July 1, 1878, outstanding liabilities	7 67	
		4,92
July 1, 1878, amount available		10,00
Amount (estimated) required for completion of existing project		65,00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		65,00

(See Appendix F F 3.)

4. *Improvement of Sandusky City Harbor, Ohio.*—During the fiscal y the work of dredging the west or main channel through Sandusky H was continued; it was confined, principally, to the outer reach, or ou bar, near Cedar Point, the cut through which was only partially c pleted; also to the east and west range, and the north and south ran and the widening of the elbows connecting; thus making a clear chan way between the 15-foot curve of the lake and the 12-foot curve of bay. Several cuts were also made along the last reach toward the c

The work was done under two contracts, one of which was clo during the year. The whole amount dredged under both contracts fr the commencement of the work until the end of the last fiscal y amounted to 145,421 cubic yards, at a cost of $22,094.90. The dredg during the present year will be confined to the "Illuminated Clo range and to the completion of the cut through the outer bar.

July 1, 1877, amount available	$21,771 91	
Amount appropriated by act approved June 18, 1878	20,000 00	
		$41,771
July 1, 1878, amount expended during fiscal year	16,616 76	
July 1, 1878, outstanding liabilities	2,250 05	
		18,86
July 1, 1878, amount available		22,90
Amount (estimated) required for completion of existing project		1,000
Amount that can be profitably expended in fiscal year ending June 30, 1880.		1,000

(See Appendix F F 4.)

Improvement of Huron Harbor, Ohio.—During the last fiscal year no
was accomplished, as no money was available for the purpose.
repairs will be made to the piers in the course of the present year,
all appropriation having been made to meet the expense.

, 1877, amount available	$189 17	
nt appropriated by act approved June 18, 1878	1,000 00	
		$1,189 17
, 1878, amount available		1,189 17

e Appendix F F 5.)

Improvement of Vermillion Harbor, Ohio.—During the fiscal year needed improvements and repairs were made to the piers, and ll soundings made to ascertain the cost of blasting and removal of ock and dredging the sand and gravel from the canal or artificial r. During the present season it is proposed to open a channel-0 feet in width with a depth of 13 feet at average low stage of . The amount of funds available is deemed sufficient for the pur- Some slight repairs to piers are still needed.

1877, amount available	$4,113 85	
t appropriated by act approved June 18, 1878	4,000 00	
		$8,113 85
1878, amount expended during fiscal year		1,074 35
1878, amount available		7,039 50

Appendix F F 6.)

mprovement of Black River Harbor, Ohio.—No work was accom- l during the last fiscal year for want of funds. With the small priation of June 18, 1878, the damage to the east pier, caused by ing vessel, will be repaired, and several other slight repairs will e attention.

1877, amount available	$52 89	
t appropriated by act approved June 18, 1878	1,000 00	
		$1,052 89
1878, amount expended during fiscal year	43 04	
1878, outstanding liabilities	9 85	
		52 89
1878, amount available		1,000 00

Appendix F F 7.)

OVEMENT OF HARBORS ON LAKE ERIE EAST OF BLACK RIVER, AND ON LAKE ONTARIO AND THE RIVER SAINT LAWRENCE.

cer in charge, Maj. Walter McFarland, Corps of Engineers, with M. B. Adams, Corps of Engineers, under his immediate orders. harbors on Lake Erie were in charge of Lieut. Col. C. E. Blunt, of Engineers, until January 1, 1878.

onstruction of breakwater at Cleveland, Ohio.—The substructure breakwater has been extended, under contract, 300 feet, by the n of 6 cribs, each 50 feet long, resting upon a riprap foundation. close of the season this will be farther extended under the old riation 100 feet and the superstructure will be added, making gth of the completed work 1,217 feet.
r the new appropriation it is expected that a further extension feet will be secured.

E

July 1, 1877, amount available	$35,273 28	
Amount appropriated by act approved June 18, 1878	100,000 00	
		$135,273 28
July 1, 1878, amount expended during fiscal year	6,782 50	
July 1, 1878, outstanding liabilities	6.405 02	
		13,187 52
July 1, 1878, amount available		122,085 76
Amount (estimated) required for completion of existing project		1,600,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		300,000 00

(See Appendix G G 1.)

2. *Repairs of east pier at Cleveland, Ohio.*—The balance of the appropriation of August 14, 1876, was applied to the completion of the pile-protection begun in April, 1877, in front of that part of the east pier occupied by the Cleveland and Pittsburgh Railroad Company.

As this company is now responsible for the care of this part of the pier, no further appropriation for it will be needed.

July 1, 1877, amount available	$3,504 25
July 1, 1878, amount expended during fiscal year	3,504 25

(See Appendix G G 2.)

3. *Improvement of Fairport Harbor, Ohio.*—Nothing has been done here during the year, there being no appropriation available.

The appropriation of $5,000, made by act approved June 18, 1878, will be applied to necessary repairs of piers and dredging.

July 1, 1877, amount available	$5 48	
Amount appropriated by act approved June 18, 1878	5,000 00	
		$5,005 48
July 1, 1878, amount expended during fiscal year		5 48
July 1, 1878, amount available		5,000 00

(See Appendix G G 3.)

4. *Improvement of Ashtabula Harbor, Ohio.*—The west pier was repaired and extended 40 feet under the balance of the appropriation of August 14, 1876.

The $12,000 appropriated by act of June 18, 1878, will be applied to the extension of the east pier, bringing its head abreast of the head of the west pier.

July 1, 1877, amount available	$6,584 16	
Amount appropriated by act approved June 18, 1878	12,000 00	
		$18,584 16
July 1, 1878, amount expended during fiscal year		4,597 01
July 1, 1878, amount available		13,987 15
Amount (estimated) required for completion of existing project		18,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		18,000 00

(See Appendix G G 4.)

5. *Improvement of Conneaut Harbor, Ohio.*—Nothing has been done here during the past year. The harbor is in good condition and requires no additional appropriation for the present.

July 1, 1877, amount available	$53 50
July 1, 1878, amount available	53 50

(See Appendix G G 5.)

6. *Improvement of Erie Harbor, Pennsylvania.*—The catch-sand fence at the neck of the peninsula was extended 500 feet.

A length of 300 feet of the superstructure of the north pier was rebuilt

and the channel was dredged for 850 hours, or 85 days of 10 hours each, 30,000 cubic yards being the estimated amount of material removed.

The appropriation of June 18, 1878, will be applied to a continuation of this same work.

July 1, 1877, amount available	$28,521 86	
Amount appropriated by act approved June 18, 1878	25,000 00	
		$53,521 86
July 1, 1878, amount expended during fiscal year	12,270 65	
July 1, 1878, outstanding liabilities	461 57	
		12,732 22
July 1, 1878, amount available		40,789 64
Amount (estimated) required for completion of existing project		94,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		40,000 00

(See Appendix G G 6.)

7. *Improvement of Dunkirk Harbor, New York.*—During the year the breakwater has been extended eastwardly 251 feet, which nearly exhausted the appropriation of August 14, 1876. The balance remaining will be applied to the repair of the west pier.

To complete the scheme for the improvement of this harbor would require the extension of this breakwater 2,500 feet farther, at an estimated cost of $162,000.

There appears to be no immediate necessity for the construction of more than one-fifth of this, the estimated cost of which is $31,000.

July 1, 1877, amount available		$15,704 62
July 1, 1878, amount expended during fiscal year	$8,175 51	
July 1, 1878, outstanding liabilities	5,028 55	
		13,204 06
July 1, 1878, amount available		2,500 56
Amount that can be profitably expended in fiscal year ending June 30, 1880.		31,000 00

(See Appendix G G 7.)

2. *Improvement of Buffalo Harbor, New York.*—The breakwater has been extended southerly 150 feet, a part of the superstructure, however, not being finished at the close of the fiscal year.

The total length of breakwater now constructed is 3,074 feet.

The $80,000 appropriated by act approved June 18, 1878, will permit a further extension of about 350 feet.

July 1, 1877, amount available	$36,522 37	
Amount appropriated by act approved June 18, 1878	80,000 00	
		$116,522 37
July 1, 1878, amount expended during fiscal year	12,829 91	
July 1, 1878, outstanding liabilities	11,579 45	
		24,409 36
July 1, 1878, amount available		92,113 01
Amount (estimated) required for completion of existing project		1,735,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		300,000 00

(See Appendix, G G 8.)

9. *Improvement of Wilson Harbor, New York.*—That part of the west pier, 120 feet in length, which was breached by the sea last year, has been rebuilt, and the channel between the piers has been dredged out to a depth of 9 feet, 14,302 cubic yards of sand being removed.

The scheme for the improvement of this harbor provides for the extension of the piers to the 12-foot curve, and the deepening of the channel to 12 feet, at an estimated cost of $80,000. There appears to be no

immediate necessity for this, however, and no further appropriation now asked for.

July 1, 1877, amount available		$10,018
July 1, 1878, amount expended during fiscal year	$5,171 16	
July 1, 1878, outstanding liabilities	1,418 56	
		6,589
July 1, 1878, amount available		3,428
Amount (estimated) required for completion of existing project		80,000

(See Appendix G G 9.)

10. *Improvement of Olcott Harbor, New York.*—Nothing has been do here during the year, the appropriation of March 3, 1875, being esse tially exhausted.

The scheme for the improvement of this harbor provides for the exte sion of the piers 100 feet farther and some channel work, at an estimat cost of $10,000 which can be profitably expended in the coming year.

July 1, 1877, amount available	$63
July 1, 1878, amount expended during fiscal year	63
Amount (estimated) required for completion of existing project	10,000
Amount that can be profitably expended in fiscal year ending June 30, 1880	10,000

(See Appendix G G 10.)

11. *Improvement of Oak Orchard Harbor, New York.*—Extensive repa have been made in the west pier, which had settled in several plac and a breach formed at the inner end of the east pier has been par closed by crib-work.

The appropriation of June 18, 1878, will be applied to the complet of these repairs.

July 1, 1877, amount available	$2,001 52	
Amount appropriated by act approved June 18, 1878	2,000 00	
		$4,001
July 1, 1878, amount expended during fiscal year		1,574
July 1, 1878, amount available		2,426
Amount (estimated) required for completion of existing project		2,000
Amount that can be profitably expended in fiscal year ending June 30, 1880		2,000

(See Appendix G G 11.)

12. *Improvement of Charlotte Harbor, New York.*—Nothing has be done here during the year, there being no money available.

The appropriation of June 18, 1878, will be applied to the repair the piers.

The improvement of this harbor as far as designed has been co pleted.

July 1, 1877, amount available	$22 54	
Amount appropriated by act approved June 18, 1878	1,000 00	
		$1,022
July 1, 1878, amount expended during fiscal year		22
July 1, 1878, amount available		1,000
Amount that can be profitably expended in fiscal year ending June 30, 1880		1,000

(See Appendix G G 12.)

13. *Improvement of Pultneyville Harbor, New York.*—The east pier l been extended shoreward 90 feet.

The shore end of the west pier has been rebuilt for 150 feet and t outer ends of both piers have been repaired.

The appropriation of June 18, 1878, will be applied to closing t

g between the shore and the inner end of the east pier, and further

1877, amount available	$3,039 44	
appropriated by act approved June 18, 1878	5,000 00	
		$8,039 44
1878, amount expended during fiscal year		2,415 93
1878, amount available		5,623 51
(estimated) required for completion of existing project		13,000 00
that can be profitably expended in fiscal year ending June 30, 1880		13,000 00

Appendix G G 13.)

mprovement of Great Sodus Harbor, New York.—The west pier ensively repaired and 200 feet of the inner end of it was rebuilt. nd-catch fence 250 feet in length was built to prevent the beach om blowing into the channel.

appropriation of June 18, 1878, will be applied to completing the and to dredging the channel.

1877, amount available	$6,472 09	
appropriated by act approved June 18, 1878	5,000 00	
		$11,472 09
1878, amount expended during fiscal year		3,571 23
1878, amount available		7,900 86
(estimated) required for completion of existing project		5,000 00
that can be profitably expended in fiscal year ending June 30, 1880		5,000 00

Appendix G G 14.)

mprovement of Little Sodus Harbor, New York.—The inner end of t pier has been extended landward 150 feet, and parts of the ructure of the west pier, amounting in all to 350 feet in length, en partly rebuilt and leveled up.

appropriation of June 18, 1878, will be applied to further repairs piers and to dredging the channel.

1877, amount available	$5,856 57	
appropriated by act approved June 18, 1878	10,000 00	
		$15,856 57
1878, amount expended during fiscal year		3,911 40
1878, amount available		11,945 17
(estimated) required for completion of existing project		7,000 00
that can be profitably expended in fiscal year ending June 30, 1880		7,000 00

Appendix G G 15.)

mprovement of Oswego Harbor, New York.—The new breakwater n extended 423 feet, which makes its present length 4,116 feet. irs to the amount of $3,500 have been made to the older parts of ucture where settlement had taken place, and repairs to the of $3,000 have been made to the old breakwater.

appropriation of $90,000 made for this improvement by act of ss approved June 18, 1878, will, besides the usual repairs, permit nsion of the breakwater of between 600 and 700 feet.

1877, amount available	$58,470 01	
appropriated by act approved June 18, 1878	90,000 00	
		$148,470 01
1878, amount expended during fiscal year		53,497 11
1878, amount available		95,072 90
(estimated) required for completion of existing project		45,000 00
that can be profitably expended in fiscal year ending June 30, 1880		30,000 00

Appendix G G 16.)

17. *Improvement of Ogdensburg Harbor, New York.*—Nothing has been expended here, there being no funds available.

The scheme for the improvement of this harbor provided for a pile protection to the channel at an estimated cost of $70,000.

There appears to be no present necessity for the construction of this work, and no appropriation is therefore asked for it.

July 1, 1877, amount available	$15 08	
December 11, 1877, amount allotted from appropriation for "repairs of harbors on Northern Lakes"	5 56	
		$20 64
July 1, 1878, amount expended during fiscal year		20 64
Amount (estimated) required for completion of existing project		70,000 00

(See Appendix G G 17.)

18. *Improvement of Waddington Harbor, New York.*—Nothing has been done here during the year, there being no funds available.

The appropriation of $5,000 made by act of Congress approved June 18, 1878, will be applied to channel-work.

Amount appropriated by act approved June 18, 1878	$5,000 00
July 1, 1878, amount available	5,000 00

(See Appendix G G 18.)

PACIFIC COAST.

IMPROVEMENT OF OAKLAND AND WILMINGTON HARBORS AND OF THE SACRAMENTO AND FEATHER RIVERS, CALIFORNIA.

Officer in charge, Maj. G. H. Mendell, Corps of Engineers.

1. *Improvement of Oakland Harbor, California.*—The north jetty was extended during the year for a distance of 540 feet and the south jetty a distance of 960 feet. The lengths of the jetties north and south are, respectively, 9,500 feet and 12,000 feet. The stone consumed by the operations of the year amounted to 25,162 tons.

The jetties are as yet in an unfinished state and will require to be raised several feet.

The dredging of a channel between the jetties was in progress at the beginning of the fiscal year and has been completed. The amount of dredging done in the year was 13,420 cubic yards. The completed channel was 200 feet in width and 10 feet in depth.

A recent examination showed that the width and depth in the upper part of the channel were more than maintained, and that this part is gradually acquiring the full dimensions due to the volume of tidal water which ebbs and flows into the estuary.

In the lower part of the channel, on the other hand, there has been a slight decrease in the cross-section of the channel, not enough to affect the navigation sensibly, but enough to indicate that the volume of water now passing between the jetties in their lower part is hardly sufficient to maintain the existing cross-section.

The operations of the coming year will in part be directed to raising the jetties several feet, which will counteract any tendency that exists to lessen the sectional area of the channel.

It is possible that the commerce and travel in the harbor, which have increased remarkably, may require the channel to be widened to 300 feet. If this shall be the case, the dredging ought not to be undertaken until the raising of the walls is in progress.

July 1, 1877, amount available	$62,965 24	
Amount appropriated by act approved June 18, 1878	80,000 00	
		$142,965 24
July 1, 1878, amount expended during fiscal year		43,322 43
July 1, 1878, amount available		99,642 81
Amount (estimated) required for completion of existing project		980,435 20
Amount that can be profitably expended in fiscal year ending June 30, 1880.		200,000 00

(See Appendix H H 1.)

2. *Improvement of Wilmington Harbor, California.*—The works and public property were under the charge of a keeper throughout the year, all operations being suspended for want of funds. There has been an improvement of 1 foot in the depth of the channel, so that now there is a depth of 9 feet at mean low-water, where there was but 8 a year ago.

A portion of the timber-work, 330 feet in length, has been seriously injured by the *Teredo navalis*, and will require protection during the coming year. The stone jetties at the entrance of the harbor have been flattened by the action of the sea, and will need to be raised 2 or 3 feet. The outer end of the west jetty was injured by the storms of the past winter, which were unusually severe. Otherwise, no injury which will not right itself was done.

The sand has increased in height at the upper end of the work and has become more stable under the protection of a sand plant which was sown and grew very well.

Farther out there has been no increase in sand, and in some places rather a loss.

The funds available for the operations of the coming year, $20,000, will be expended in stone to be placed on lines of the work, and will probably be expended before the expiration of the year 1878. The estimate for the completion of the work is $80,000, which the officer in charge suggests should be given in two successive appropriations.

July 1, 1877, amount available	$943 42	
Amount appropriated by act approved June 18, 1878	20,000 00	
		$20,943 42
July 1, 1878, amount expended during fiscal year		943 42
July 1, 1878, amount available		20,000 00
Amount (estimated) required for completion of existing project		80,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		40,000 00

(See Appendix H H 2.)

3. *Improvement of Sacramento and Feather Rivers, California.*—The Sacramento has a navigable channel 210 miles in length. The upper 60 miles is very much obstructed by snags which are annually thrown into the river by freshets. The lower part of the river has a few snags, but it has shoals which are a great obstruction.

The Feather River has a navigable length of about 35 miles; it contains some snags, but not many. The obstruction to navigation is here due to shoals. The difficulties are easily removed, but the cure is not permanent. It has a small trade.

The appropriation made in 1875 of $15,000 was expended, w i exception of a small remainder on the upper 60 miles of the Sacramento and on the Feather, and it is proposed to devote the greater part of the funds now available to the same objects. The Lower Sacramento has not yet received attention. It needs it in the shape of a survey first, and of improvement of its shoals if this shall appear to be practicable.

The Sacramento and Feather Rivers were both examined in the spring

in reference to the expenditure of available funds in the present season. These funds will be mainly expended during the summer.

The appropriation of 1875, which was $15,000, was the first ever made for these rivers, and that of 1878 is the second. The total amount thus far appropriated is $30,000.

July 1, 1877, amount available	$243 25	
Amount appropriated by act approved June 18, 1878	15,000 00	
		$15,243 25
July 1, 1878, amount expended during fiscal year		59 40
July 1, 1878, amount available		15,183 85
Amount that can be profitably expended in fiscal year ending June 30, 1880.		20,000 00

(See Appendix H H 3.)

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

To comply with provisions of the river and harbor act of June 18, 1878, Lieut. Col. B. S. Alexander, Corps of Engineers, has been charged with and is now engaged upon examinations and surveys at the following localities, the results of which will be duly submitted when received:

1. *Crescent City Harbor, California, with a view to its adaptability as a harbor of refuge.*

2. *Humboldt River, California, with a view to its adaptability as a harbor of refuge.*

IMPROVEMENT OF THE HARBOR AT SAN DIEGO—IMPROVEMENT OF SAN JOAQUIN RIVER, CALIFORNIA.

Officer in charge, Lieut. Col. C. S. Stewart, Corps of Engineers.

1. *Improvement of harbor at San Diego, California.*—Owing to a cloudburst on October 14, 1877, some damage was done to the earthen levee, which was repaired before winter set in. The rains of the wet season have made a few holes in this embankment to be repaired during this autumn. The appropriation for this work is about exhausted, and the money on hand will be expended on repairs referred to above. A new appropriation for yearly repairs is needed. These may probably cost from $200 to $300 after each wet season.

July 1, 1877, amount available	$201 74
July 1, 1878, amount expended during fiscal year	133 52
July 1, 1878, amount available	68 22
Amount that can be profitably expended in fiscal year ending June 30, 1880, and succeeding years, for repairs	1,000 00

(See Appendix I I 1.)

2. *Improvement of San Joaquin River, California.*—During August and September, 1877, a survey was made of this river below Stockton. In December a contract to remove portions of a point at the outlet of Burns's Cut-off and at the Devil's Elbow and to dredge certain shoals in the narrows was entered into, and the work begun on December 27, 1877, and finished April 17, 1878. Total amount of material removed, 23,013 cubic yards. The plan of improvement adopted is completed. It is proposed to make a resurvey with funds on hand during the coming fiscal year.

July 1, 1877, amount available	$19,923 20
July 1, 1878, amount expended during fiscal year	19,363 29
July 1, 1878, amount available	629 91

(See Appendix I I 2.)

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

To comply with the provisions of the river and harbor act, June 18, 1878, Lieutenant-Colonel Stewart has been charged with and is now engaged upon examinations and surveys at the following localities, the results of which will be duly submitted when received:

1. *The harbor of San Luis Obispo, California, with a view to the practicability of building breakwater.*
2. *The harbor of San Buenaventura, California, with a view to the practicability of building breakwater.*
3. *The harbor of Santa Barbara, California, with a view to the practicability of building breakwater.*
4. *Colorado of the West, from Fort Yuma to El Dorado Cañon.*

IMPROVEMENT OF RIVERS IN OREGON AND IN WASHINGTON TERRITORY—CONSTRUCTION OF CASCADES CANAL, COLUMBIA RIVER.

Officer in charge, Maj. John M. Wilson, Corps of Engineers.

1. *Improvement of the Lower Willamette and Columbia Rivers, Oregon.*—Operations during the year have consisted of dredging at the mouth of the Willamette and at Swan Island Bar, Willamette River, and at Saint Helen's Bar, Columbia River.

Surveys have been made at Swan Island, Post Office, mouth of Willamette and Saint Helen's Bars, and at Sand Island, mouth of Columbia River.

Extensive repairs have been made upon the United States dredge and scows.

During the present season it is proposed to continue dredging the channel over the bars in the Willamette River and at Saint Helen's in the Columbia, and to scrape the bar at Snag Island, Lower Columbia.

July 1, 1877, amount available	$18,584 54
Amount appropriated by act approved June 18, 1878	30,000 00
	48,584 54
July 1, 1878, amount expended during fiscal year	11,772 65
July 1, 1878, amount available	36,811 89
Amount (estimated) required for completion of existing project	268,984 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.	150,000 00

(See Appendix J J 1.)

2. *Improvement of the Upper Willamette River, Oregon.*—Operations during the fiscal year have consisted of the removal of snags and stumps, construction of wing-dams, making surveys, and preparing charts. Three thousand eight hundred and forty linear feet of wing-dams have been built, 673 trees, stumps, &c., removed from the channel, and over 100 overhanging trees cut from the banks of the river.

During the present season it is proposed to continue the removal of snags, &c., from the channel, to remove portions of Bissell's and Dove's rocks, to repair wing-dams, build short dams for sluicing out bars, and to scrape the bars where it may be found necessary.

July 1, 1877, amount available	$14,246 54	
Amount appropriated by act approved June 18, 1878	20,000 00	
		$34,246 54
July 1, 1878, amount expended during fiscal year		14,120 29
July 1, 1878, amount available		20,126 25
Amount (estimated) required for completion of existing project		60,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880		40,000 00

(See Appendix J J 2.)

3. *Improvement of the Upper Columbia and Snake Rivers, Oregon and Washington Territory.*—Operations during the fiscal year were carried on in November and December, 1877, removing rocks from the channel at the Upper Umatilla Rapids.

A survey was made of the Upper Umatilla Rapid, and a buoy located at the upper entrance to the channel.

During the coming winter it is proposed to continue work of removing rock at Five-mile and Pine Tree Rapids in the Snake River.

July 1, 1877, amount available	$5,750 09	
Amount appropriated by act approved June 18, 1878	20,000 00	
		$25,750 09
July 1, 1878, amount expended during fiscal year		5,750 09
July 1, 1878, amount available		20,000 00
Amount (estimated) required for completion of existing project		112,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880		75,000 00

(See Appendix J J 3.)

4. *Construction of canal around the Cascades of the Columbia River, Oregon.*—The plans and estimates for this canal, submitted by the officer in charge, were referred to the Board of Engineers for the Pacific Coast for examination, and having been approved by the board, with some minor changes as to the size of locks and height of the breakwater below them, the plan was finally approved by this office and by the Secretary of War. (See Appendix J J 4.)

To meet the possible future wants of commerce, the width of 50 feet recommended by the board of engineers has been increased, with the approval of the Secretary of War, to 70 feet, at an estimated increase of cost of about $30,000.

Proceedings for the condemnation of the land required for the canal were still pending at the close of the fiscal year. The amount of work that can be accomplished during the next fiscal year depends upon the time at which possession can be had.

July 1, 1877, amount available	$85,383 35	
Amount appropriated by act approved June 18, 1878	150,000 00	
		$235,383 35
July 1, 1878, amount expended during fiscal year		5,854 05
July 1, 1878, amount available		229,529 30
Amount (estimated) required for completion of existing project		1,524,338 00
Amount that can be profitably expended in fiscal year ending June 30, 1880		500,000 00

(See Appendix J J 4.)

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

To comply with provisions of the river and harbor act of June 18, 1878, Major Wilson has been charged with and is now engaged upon

examinations and surveys at the following localities, the results of which will be duly submitted when received:

1. *The entrance of Coos Bay.*
2. *Cape Foulweather, Oregon, to ascertain its adaptability as a harbor of refuge.*
3. *Clearwater River, Idaho.*
4. *Port Orford, Oregon, to ascertain its adaptability for a harbor of refuge.*
5. *Rogue River, Oregon, between Scottsburg and its mouth.*
6. *Coquille River, Oregon.*
7. *Alsea River and Bay, Oregon.*

IMPROVEMENT AND CARE OF PUBLIC BUILDINGS AND GROUNDS IN THE DISTRICT OF COLUMBIA—WASHINGTON AQUEDUCT.

Officer in charge, Lieut. Col. Thos. Lincoln Casey, Corps of Engineers.

1. *Improvement and care of Public Buildings and Grounds in the District of Columbia.*—The condition of the public reservations in the city of Washington, and the character of the improvements made on them, will be found stated in the detailed report of the officer in charge. His estimates for the fiscal year ending June 30, 1880, are as follows:

For improvement and care of public buildings and grounds	$145,200 00
For compensation to persons employed on and around public buildings and grounds	42,320 00
	187,520 00

(See Appendix KK 1.)

2. *Washington Aqueduct.*—The amount appropriated by Congress for the fiscal year ending June 30, 1878, was $15,000. This has been expended in widening and strengthening embankments, and keeping the roads, bridges, culverts, reservoirs, gate-houses, pipe line, &c., in repair, together with supervising the general distribution of Potomac water in the conduits, reservoirs, and iron mains.

The estimates of the officer in charge for the fiscal year ending June 30, 1880, are as follows:

For engineering, maintenance, repairs, and construction	$116,000

(See Appendix KK 2.)

SURVEYS AND EXAMINATIONS WITH A VIEW TO THE IMPROVEMENT OF RIVERS AND HARBORS.

For examinations and surveys of rivers and harbors for which there is no special appropriation, an appropriation of $150,000 should be made.

SURVEY OF NORTHERN AND NORTHWESTERN LAKES AND THE MISSISSIPPI RIVER.

Officer in charge, Maj. C. B. Comstock.

During the temporary absence of Major Comstock, the work was in charge of Capt. H. M. Adams, who had under his immediate orders First Lieuts. D. W. Lockwood, C. F. Powell, and P. M. Price, and the following principal assistant engineers: O. B. Wheeler, E. S. Wheeler, A. R. Flint, G. Y. Wisner, R. S. Woodward, A. C. Lamson, F. M. Towar, F. Terry, A. T. Morrow, J. H. Darling, and F. W. Lehnartz.

Progress of the work during the year.—On Lake Erie the triangulation has been carried from Cleveland, Ohio, to the west end of the lake. The topography and hydrography have been extended to include all of

the American shore, and the Canadian shore from Detroit River to Point Pelée. A base-line has been measured near Chicago and the connecting triangulation east has been completed to White Pigeon, Mich.

The latitude and longitude of Memphis, Tenn., have been determined, and in connection with Capt. W. S. Stanton, United States Engineers, the longitudes of Fort Laramie, Wyo., Camp Robinson, Neb., and Deadwood, Dak., have been determined.

The survey of the Mississippi River has been carried from Mound City, above Memphis, to Scanlon's Landing, Ark., and a line of precise levels has been completed from Memphis, Tenn., to Austin, Miss.

A chart of Lake Ontario, coast charts Nos. 1 and 2 Lake Ontario, coast charts Nos. 7, 8, and 9 Lake Michigan, and detail charts Nos. 1, 2, 3, 4, 5, 6, and 7 Mississippi River have been completed.

Amount available for fiscal year 1878–'79	$99,000 00
Amount required for fiscal year ending June 30, 1880, namely, for completion of triangulation south from Chicago and east to Lake Erie; for reduction of work and construction of maps, for determining points in aid of State surveys, and miscellaneous	85,000 00
For continuing the survey of the Mississippi River and its tributaries with a view of determining the proper method of reclaiming from overflow the alluvial lands of the Mississippi Delta and improving the navigation of the river	158,660 00

(See Appendix L L.)

MAPS OF CAMPAIGNS AND BATTLE-FIELDS.

The map of the battle-field of Gettysburg, in three sheets, showing the positions of the two armies on the mornings and evenings of July 1, 2, and 3, prepared under the direction of Maj. G. K. Warren, has been completed and distributed.

The field of the important operations of August 28, 29, and 30, 1862, near Groveton, Va., never having been surveyed by the Engineer Corps, an allotment of $1,000 for this purpose was made early in June, 1877, and the duty assigned to Major Warren of making such survey as the means would allow. This survey was in progress at the close of the fiscal year.

MILITARY, GEOGRAPHICAL, AND LAKE-SURVEY MAPS.

In the Office of the Chief of Engineers.

The compilation of the Atlanta campaign maps has been completed, and an addition has been photolithographed, and distributed to the military posts.

Considerable progress has been made in the compilation and drawing of a new edition of the map of the territory of the United States west of the Mississippi River, scale $\frac{1}{500.000}$. It is hoped that this map will be ready for publication early in the coming year.

The maps of Montana and Dakota have been revised by Lieut. Edward Maguire, Corps of Engineers, Chief Engineer Department of Dakota, and are now in the hands of the engraver.

Atlas sheet No. 10 of the Territory of Arizona, compiled at headquarters Department of Arizona, has been received. It will be photolithographed, and an edition printed for distribution to the Army.

A map showing the defenses of Cincinnati, Covington, and Newport during the late war has been photolithographed and printed.

A map of the Mississippi River between the Illinois and Ohio Rivers

(in nine sheets), from surveys by Lieut. Col. W. F. Raynolds and Col. J. H. Simpson, has been photolithographed and an edition printed.

A map of the Mississippi River, from the Falls of Saint Anthony to the mouth of the Illinois (in twenty-six sheets), compiled from surveys of Maj. G. K. Warren and Col. J. N. Macomb, Corps of Engineers, by Maj. F. U. Farquhar, Corps of Engineers, is now in the hands of the photolithographer, in order that an edition may be printed.

Thirty-seven detail drawings of Des Moines Rapids locks and canal, of the Mississippi River, have been engraved on stone and an edition printed.

Lake-survey charts Nos. 1, 2, and 3 of the Mississippi River near Cairo, and charts Nos. 4, 5, 6, and 7 near Memphis, have been photolithographed.

Lake-survey charts of Lake Ontario, Lake Ontario coast charts Nos. 1 and 2, Lake Michigan coast charts Nos. 8 and 9 have been photolithographed, and an edition printed in advance of the engraved edition. These charts are now in the hands of the engraver; Lake Michigan coast chart No. 4 is also in the hands of the engraver, a photolithographic edition having been printed in advance.

The following lake-survey charts have been engraved on copper, viz:

Chart of Detroit River.
Lake Michigan coast chart No. 1.
Lake Michigan coast chart No. 2.
Lake Michigan coast chart No. 6.
Lake Michigan coast chart No. 7.
Saint Lawrence River chart No. 5.
Saint Lawrence River chart No. 6.

GEOLOGICAL EXPLORATION OF THE FORTIETH PARALLEL.

Mr. Clarence King, United States civil engineer, in charge.

During the year the operations of this survey have been entirely confined to the office, consisting in superintendence of publication of the atlas and text.

Leave of absence was granted Mr. King from July 1, 1877, till October 31, 1877, and during that interval, there being no employés attached to his office, the operations of the work were suspended.

Active work was resumed November 1 and continued to date. Throughout that time the force of the office has consisted of himself and one general assistant.

The entire interval has been devoted to the revision of the manuscript of volume I, "Systematic Geology," of the series of reports, and the printing of the same.

Composition has proceeded at the office of the Public Printer up to page 676.

The manuscript is all done, and will carry the text up to about 760 pages.

It is estimated that the volume and index will be all stereotyped by August 10 or 15, and printed and bound by the end of September.

During the year the illustrations of volume VII, Vertebrate Palæontology, have been completed and paid for. Professor Marsh has made good progress with the manuscript of volume VII, and expected to have it completed by early winter.

During the year volumes IV, Palæontology and Ornithology, and II, Descriptive Geology, have been finished by the Public Printer and distributed.

The General Topographical and Geological Atlas has also been distributed in part.

For the completion of the whole work there only remain the few additional pages of printing on volume I and the text of volume VII.

(See Appendix M M.)

GEOGRAPHICAL SURVEYS OF THE TERRITORY OF THE UNITED STATES WEST OF THE ONE-HUNDREDTH MERIDIAN.

Officer in charge, First Lieut. George M. Wheeler, Corps of Engineers, having under his orders First Lieuts. Eric Bergland, Samuel E. Tillman, and Thomas W. Symons, and Second Lieuts. Eugene Griffin and Willard Young, Corps of Engineers; First Lieut. Rogers Birnie, jr., Ordnance Department; First Lieut. Charles C. Morrison, Sixth Cavalry; Second Lieuts. Benjamin H. Randolph and Henry H. Ludlow, Third Artillery; and Second Lieut. M. M. Macomb, Fourth Artillery.

During the year the following gentlemen have been engaged in the investigation of special subjects: Dr. F. Kampf, astronomer, triangulation observer, and computer; John A. Church, mining engineer; A. R. Conkling, geological assistant; H. W. Henshaw, ornithologist.

Dr. F. Kampf died at his residence in Washington after a short illness, resulting from a concussive blow upon the forehead, accidentally received while on duty in the field.

Dr. J. T. Rothrock, professor of botany at the University of Pennsylvania, has devoted considerable time to the final preparation of the manuscript for volume VI, and now, with the assistance of the colaborers in this branch, is engaged in reading proof.

Prof. F. W. Putnam, curator of the Peabody Museum, Cambridge, Mass., has, at intervals taken from his other professional labors, advanced nearly to completion his part of the manuscript of volume VII of the quarto reports, and has superintended the preparation and production of the illustrative cuts.

Prof. John J. Stevenson, late of the Pennsylvania State geological survey, and member of the expedition of 1873, resumes his labors upon Western geology, and will pay especial attention during the coming season to the outcrops of the Coal Measures at the east base of the Rocky Mountain ranges of Colorado and New Mexico.

The funds appropriated for this survey by the act approved March 3, 1877, having been made immediately available, the members of the expedition of this year were enabled to take the field early in May, during which month the entire working field force of the survey, consisting of three sections, known as the Colorado, Utah, and California, composed of ten parties, was effectively organized and engaged in the prosecution of its labors.

The several parties were distributed in those portions of California, Oregon, Nevada, Utah, Idaho, Montana, Wyoming, Colorado, New Mexico, and Texas embraced by atlas sheets 23 B, 32 C, 32 D, 38 B, 38 D, 41 A, 41 B, 47 B, 48 D, 52 D, 56 B, 61 A, 77 D, and 84 B. (See Progress map accompanying Appendix NN.) The field season, as usual, was extended as late as the early and extreme cold of the mountain regions visited would permit. The parties, during the latter days of November and early part of December, disbanded at Carson, Nev., Ogden, Utah, Fort Garland, Colo., and Fort Union, N. Mex.

The drainage basins occupied were portions of the northwestern arm of the "great interior basin," and those of the Pecos, Rio Grande, Arkansas, Gunnison and its tributaries, Bear and Snake rivers, and creeks

entering the latter from the south, together with areas bordering on several streams of various magnitudes debouching from the Sierra Nevadas upon the great inland valleys of Central California.

During the month of March, a special topographical and hydrographical survey of the Great Salt Lake basin was begun. This contemplates, in addition to the detailed topographical survey of the entire basin that has Great Salt Lake as its reservoir, an accurate meander of the shores of the lake and its islands, with the soundings needed to determine its present volume, observations upon the evaporation at the surface, with periodic rise and fall, the measurement at different seasons of the inflow and rainfall, and other meteorological observations at stations located upon the incoming streams. The Jordan, Weber, and Bear rivers, the principal sources of supply, were measured. Nearly two-thirds of the meander has been completed, and a number of soundings made. The continuation, at a trifling expense, of this work, will be prosecuted, as circumstances permit, from the Ogden office of the survey.

While the expeditionary parties are engaged in the field, a small annual office force is employed in completing the necessary computations and the delineation of the final atlas sheets. A temporary field office was established at Ogden, Utah, during the past winter, and will hereafter be occupied by such of the assistants as may be available. Such field astronomical latitude stations only as have been found requisite for checking the measured lines of survey through mountain passes, cañon defiles, and along routes from which main and secondary triangulation points are not visible, have been determined.

The project submitted for the season of 1878 contemplated the establishment of at least five longitude and latitude determinations at main stations, selected at positions favorable for checking the extended belts of triangulation. During the season of 1877 five bases were measured, at the following points: (1) Ogden, Utah; (2) between Terrace, Utah, and Lucin, Utah, on the Central Pacific Railroad; (3) near Austin, Nev.; (4) near Bozeman, Mont.; (5) near Verdi, Nev., on the Central Pacific Railroad. In each case connection was made with the initial astronomical stations in the vicinity and with the vertices of triangles of the main belts adjacent. During the same season 145 sextant latitude stations were occupied, 56 triangles about bases measured, and observations made at 106 main and 264 secondary triangulation stations, 2,474 three-point and cross-sight stations, and 12,366 minor points occupied.

Magnetic variations were determined at 424 points and 10,801 miles measured. The necessary observations were made at 10,438 cistern and aneroid barometer stations for differences of altitude. The locations of 60 mineral and thermal springs have been defined, and 19 mining camps visited. A number of lots and specimens of minerals, fossils, mammals, birds, reptiles, fishes, insects, shells, &c., have been collected.

In the office, 106 astronomical positions have been computed, 87 stations adjusted by method of least squares, 1,149 triangles, 2,298 distances, 295 longitudes and latitudes, and 352 azimuths computed, and 1,356 cistern barometer and 7,798 aneroid altitudes have been computed.

There have been 14 sheets and parts of sheets plotted on a scale of 1 inch to 2 miles, and 6 special sheets drawn to various scales.

The number of final or completed atlas sheets drawn and submitted with the report for the year is nine; 1,542 reports and 12,768 maps have been distributed. The increasing call for reports and maps from various sections of the country, and notably from those interested in the settlement of these western regions, is an indication that the results of the survey to a certain extent meet a popular want.

After the passage of the appropriation for this survey on the 20th of June, the regular parties, nine in number, of which two admit of operating as double parties, consisting of forty-six observers, took the field early in July in three divisions, known as the Colorado, Utah, and California sections.

Three main astronomical parties also proceeded to their respective posts for the purpose of establishing the longitude, latitude, and altitude of stations at Walla Walla, Washington Ter.; Dalles, Oreg.; Fresno, Cal.; Fort Bliss, Tex.; and Fort Bayard, N. Mex. These parties, twelve in all, are distributed in the following political divisions: Two in California; one in parts of Nevada, California, and Oregon; three in parts of Nevada and California; one in Utah; one in Oregon and California; two in Colorado and New Mexico; two in New Mexico and Texas; and in areas embraced by atlas sheets Nos. 12, 20, 29, 38, 47, 56, 48, 73, 80, 41, 70, 78, 84, and 90. (See Progress map of 1878.) The Washington office continues its labors as usual. The expedition of 1878, larger than any other in number of observers, takes the field well equipped, and the season, when prolonged as intended until December, will admit of still further accumulation of topographical data required for the thorough and vigorous prosecution toward completion of the survey needed for the detailed topographical map of the entire region.

Prof. J. J. Stevenson, with one assistant, is to be engaged during the season along the mountain ranges between the Rio Grande and the plains, and south of the Spanish Peaks, in Colorado. He will make detailed sections of the coal croppings and worked beds. Having the detailed topographical maps of this section, already published, to facilitate his labors, it is expected that the geological formations can be laid down with great rapidity and accuracy. The special examinations of the Comstock lode are being prosecuted, consisting of the completion of the detailed contour map, the following of the works in depth and along the Sutro tunnel, further data for the longitudinal, vertical, and horizontal sections, observations upon temperatures, ventilation, and drainage of the mines, and of the geology of the surface, and collections from various tunnel and other levels.

The officer in charge suggests that, were funds available, winter parties could successfully conduct their operations in the southern portion of the field and near the Mexican border, while during the summer months parties can operate north of the Pacific railroads, thus keeping an expedition permanently in the field; and this course being in the direction of a rapid completion of the work, more especially commends itself in view of the Indian campaigns of the past few years rendered necessary against the hostiles, in which the want of accurate and detailed topographical maps of the western mountain regions has been felt. And I have again the honor to suggest that the item for continuing this survey may with propriety be placed upon the Army appropriation bill. (See letter of Lieutenant Wheeler, in appendix to book of estimates for 1879 and 1880.)

Volume II (Astronomy and Barometric Hypsometry) of the quarto reports authorized to be published by act of Congress has been issued from the press, and proof reading of volume VI (Botany) is now being rapidly advanced. The tables of declinations of 2,018 latitude stars are in print and available for the special astronomical work of the present season. As soon as Vol. VI goes to press the manuscripts of Vols. I and VII, the remainder of those now approved, will be placed in the hands of the Printer. With slight exceptions, the illustrations for the above volumes have been engraved and printed.

Nine topographical sheets have been added to the atlas, and 19 others approach completion in the various stages of progress. The geological information requisite for delineation upon the sheets to accompany Vol. III, and for others of the regular atlas, is being gathered.

The special topographical sheet, on a scale of 1 inch to 1 mile, of the vicinity of Lake Tahoe, embracing the Virginia and Truckee Railroad, and that part of the Central Pacific Railroad across the Sierras, with the Washoe mining region, of the size of 6 full atlas sheets, is finally plotted and awaits publication. The plot, on a scale of 1 inch to 500 feet, of the contour survey of the vicinity of the Comstock lode, equivalent in size, when reduced to 1 inch to 1,500 feet, of four uniform atlas sheets, needs but a small amount of data for its completion. These maps, based upon a comparatively large number of computed points, are the most detailed yet produced by the survey.

Land classification maps, based upon the regular topographical sheets, are being prepared and published as fast as possible, and hereafter the notes for a more minute representation of the character of the surface of the region visited are required of the several parties in the instructions given by the officer in charge. Besides the value of these maps to the land branch of the government, they must prove of service to the emigrant settler and capitalist interested in the regions represented.

The topographical maps, which are the main results of the survey, are regularly published as fast as completed, and become at once available for the purposes of the War Department and other branches of the government service, and subsequently to the public, through the usual distribution, or, in various scales, through map publishers in this and foreign countries.

The area surveyed and mapped during the years 1869, 1871, 1872, 1873, 1874. 1875, 1876, and 1877, as reported by Lieutenant Wheeler, aggregates the amount of 332,515 square miles, distributed as follows:

	Square miles.
California	54,751
Nevada	62,181
Utah	38,969
Arizona	61,816
Colorado	33,041
Wyoming	231
New Mexico	71,427
Oregon	1,242
Idaho	8,877

Initial points have been established (including the season of 1877) in Kansas, Nebraska, Texas, Montana, and Washington. Parts of the work will have been, at the close of the season, carried on in fourteen of the fifteen of the political divisions lying west of the one hundredth meridian, and from the Columbia River on the north to the Mexican border.

The labors of this survey are annually carried on in accordance with projects regularly submitted by the officer in charge to the Chief of Engineers, and by him to the Secretary of War, by whom they are approved before the parties commence the duties of each season. These projects are in the direction of a systematic, thorough, and economic prosecution of a detailed survey in connected areas (according to a plan submitted by Lieutenant Wheeler and adopted in 1872), the necessary data being obtained by means of astronomical, geodetic, topographical and barometric observations. This work may be considered as supplemental to, binding together, and developing systematically over completed areas, by the use of more refined instruments and later methods,

the Pacific Railroad and military and geographical surveys west of the Mississippi River, suspended at the outbreak of the war of the rebellion.

Incident to the principal objects of the survey, and as far as practicable without too greatly increasing the cost, all the information necessary at the present stage of settlement of the country concerning the branches of mineralogy and mining, geology, palæontology, zoology, botany, archæology, ethnology, and philology is collected by specialists, experts in their branches of science. Information concerning this and other Engineer Department surveys in the West will be found in House Ex. Doc. 88, Forty-fifth Congress, second session. (See Appendix NN 2.)

The continuation of this most valuable and useful work, in its present stage of advancement, will, it is believed, commend itself to and receive favorable consideration from Congress.

The amount estimated by Lieutenant Wheeler for the continuation of the survey, viz, $120,000, is earnestly recommended.

His annual report, with appendixes and estimates, is appended. (See Appendix N N.)

RECONNAISSANCES AND EXPLORATIONS.

The engineer officers on the staffs of the generals commanding the military divisions and departments have been engaged during the year in surveys in the field, and in collecting and plotting geographical and other information obtained from the note-books, sketches, and maps made by the officers and soldiers in the scouts and campaigns in the West. The estimate of $50,000 made by this department for the surveys by these officers failed at the last session of Congress, thus leaving unprovided for the work which was desired to be accomplished in the seven military departments embracing the country west of the Mississippi River, in each one of which there is an engineer or acting engineer officer. This work includes surveys in the field by the department engineers, the purchase and repair of instruments, and the expenses attending the draughting and printing of maps required for distribution to the Army.

The maps of the country covered by the recent campaigns against hostile Indians have proved in the highest degree useful to the officers engaged, and it is especially desirable that the great unexplored areas in the hostile country, and areas which in future campaigns are liable to be traversed by the troops, or by the enemy, should be surveyed and plotted and added to these campaign maps. The enlistment of topographical assistants to the engineer officers attached to the headquarters of each of the Western military geographical divisions and departments, which was authorized by the Secretary of War in July, 1877, will very much facilitate the surveys of those officers, and it is hoped, if the small appropriation asked for these surveys is granted by Congress, that much more can be accomplished than has been heretofore by the same amount of expenditure.

An estimate for the amount required to be appropriated for this purpose has been included in the estimates of this department.

The officers who have been engaged on these surveys during the last fiscal year are as follows:

Maj. O. M. Poe, aid-de-camp (with the rank of colonel) to the General of the Army; Capt. G. J. Lydecker, at headquarters Military Division of the Missouri; Lieut. Edward Maguire, at headquarters Department of Dakota; Capt. W. S. Stanton, at headquarters Department of *the Platte;* Lieut. E. H. Ruffner, at headquarters Department of the

Missouri; Capt. James F. Gregory, at headquarters Department of Texas; Lieut. J. C. Mallery, at headquarters Division of the Pacific and Department of California till October 2, 1877, since which date Capt. J. H. Coster, Eighth Cavalry; Lieut. E. D. Thomas, Fifth Cavalry, at headquarters Department of Arizona till May 13, 1878, and Lieut. T. A. Touey, Sixth Cavalry, since that date.

During the fiscal year there have been distributed by Maj. H. L. Abbot, from the engineer depot at Willets Point, to officers engaged on surveys, an aggregate of 141 instruments.

(See Appendix OO.)

Capt. G. J. Lydecker, engineer officer on the staff of the Lieutenant-General, reports that for want of funds operations have been limited to current office-work, such as could be done by enlisted men detailed for the purpose; duplicate tracings of maps, sketches, &c., passing through the office, have been made, and corrections have been applied to existing maps as opportunity offered.

Captain Lydecker is of the opinion that not less than $10,000 should be available for the use of the engineer officer of each division and department west of the Mississippi River, and states that for the want of means work on his maps of the Division of the Missouri has been suspended.

(See Appendix PP.)

Lieut. Edward Maguire, at headquarters Department of Dakota, reports the topographical work in the field in that department during the year, and his report will be found in Appendix QQ.

Capt. W. S. Stanton, on duty with the general commanding the Department of the Platte, reports that during the year a reconnaissance was made of 1,328 miles of routes, embracing observations for the determination of the latitude and longitude of 44 points, including Fort Laramie, Fort McKinney, and Laramie Peak, Wyo.; Camp Robinson, Nebr.; and Custer City and Deadwood, Dak.; also for magnetic declination at 22 localities, and for altitude at 271 stations with the mercurial barometer, including a continuous series of hourly meteorological observations for 95 days by a special party at Fort Laramie. The military reservations of Fort Laramie and Fort McKinney, embracing 154 square miles, have also been surveyed, and their boundary lines established. Besides the 1,328 miles measured with odometers, the field-work involved 100 miles of chain measurement.

In the office, tables of distances between all the military posts in the department, and itineraries and descriptive notes of 3,964 miles of routes, 2,963 miles of which were measured with odometers, have been prepared, and 350 printed copies issued to officers and others needing them.

Plans, estimates, and detailed working-drawings have been prepared for a bridge to be constructed of wood and iron over the Laramie River at Fort Laramie.

The compass and odometer notes of the 1,328 miles of reconnaissance have been reduced and plotted; all the observations taken in the field for time, latitude, altitude, and magnetic declination have been computed, barometric profiles of the routes prepared, and the barometric observations for 95 days at Fort Laramie reduced and plotted.

A map has been made, on a scale of 1:600,000, of the reconnaissances of the three seasons of 1875, 1876, and 1877, embracing all important routes between the meridians of 102° 30′ and 107° 30′ and the 41st and 45th parallels. Plots have been made of the reservations surveyed, and the usual amount of routine work has been done in making tracings of

topographical sketches accompanying reports received at department headquarters.

(See Appendix R R.)

Lieut. E. H. Ruffner, on the staff of the general commanding the Department of the Missouri, reports that but little progress has been made during the past year in the preparation of maps, or in the examination and survey of new country. Want of means and small number of troops in the department available for marches or scouts are assigned as the reasons. The total mileage of journals of scouts and marches is given at 7,214, and an additional 2,030 miles for the reconnaissance in Southwest Colorado conducted by Lieut. C. A. H. McCauley, Third Artillery, assistant to Lieutenant Ruffner. This report is submitted by Lieutenant McCauley, and is considered as very valuable and of interest to all connected with that region of country.

An edition of map No. 2, Department of the Missouri, revised and corrected to date, was issued last fall. Lieutenant Ruffner submitted a second report on lines of communication between Colorado and New Mexico, which was printed as Ex. Doc. No. 66, House of Representatives, Forty-fifth Congress, second session. The report covers 38 pages of print, and is accompanied by three maps.

Lieutenant Ruffner has employed his spare time during the year in preparing a compilation or descriptive index of the reports of the Corps of Engineers for the ten years 1866–1876, entitled "A Record of Ten Years of Engineering by the Corps of Engineers, U. S. A." The manuscript is now completed.

(See Appendix S S.)

Capt. J. F. Gregory, on duty at the headquarters Department of Texas, reports that the work of his office consisted of the issues of instruments, materials, and maps to commanding officers of posts in the department, and in draughting-work, such as reducing to progress map the maps of scouts and reconnaissances made by various acting engineer officers in the department; and in making tracing of maps for use of various officers on campaigns.

Captain Gregory states that there have been plotted in his office the following maps, viz: A progress map of the department in 4 sheets, on a scale of 1 inch to 8 miles, and containing all the reliable geographical information received at his office up to date; an index map and 6 sheets of the western portion of the department, on the same scale, for photolithographing and distribution for the use of the troops of the department, and 6 reconnaissance blank sheets, also on the same scale and embracing the same areas, for printing and issue to officers, upon which can be plotted new geographical information gained in marches of troops.

(See Appendix T T.)

Lieut. J. C. Mallery, engineer officer at headquarters Division of the Pacific to October 2, 1877, reports that an examination and report was made upon the water supply of Angel and Yerba Buena Islands, California, and upon the depth of water near the quarry-wharf at Angel Island. In compliance with the orders of the commanding general, he visited San Diego, Cal., and the United States fishery reservation upon the McCloud River, California, to secure, in the first instance, the return of arms loaned by the commanding general to the city authorities, and, in the second instance, to prevent the interference by squatters with the work of the fishery. Work was continued upon the preparation of an outline description of the military reservations and posts in

the division. Maps of these military reservations and posts were nearly completed. Photographic copies of a map of Idaho Territory were issued to the troops in the field. A number of tracings were made in the ordinary routine of office-work.

Capt. J. H. Coster, Eighth Cavalry, aid-de-camp, acting engineer officer at the same headquarters since October 2, 1877, reports that the amount of money furnished him has not permitted any extensive work in the field.

Lieut. R. H. Fletcher, who was on the staff of General Howard, against the hostile Nez Percé Indians, has been engaged on a large map of the campaign which is nearly completed. A list of scouts reported at the Engineer Office, headquarters Division of the Pacific and Department of California, during the last fiscal year, is attached to Captain Coster's report.

(See Appendix U U.)

Lieut. E. D. Thomas, Fifth Cavalry, until May 13, 1877, and Lieut. T. A. Touey, Sixth Cavalry, from that date were the acting engineer officers, Department of Arizona.

The report of Lieutenant Thomas has not been received.

Lieutenant Touey reports the topographical work done in that department under his direction, and the wants of his office for the next fiscal year. His report will be found in Appendix V V.

ESTIMATES FOR AMOUNTS REQUIRED FOR MILITARY AND GEOGRAPHICAL SURVEYS, EXPLORATIONS, AND RECONNAISSANCES.

For military surveys and reconnaissances by the engineer officers attached to the various headquarters of military divisions and departments, for extra-duty pay of enlisted topographical assistants, for other military surveys, and for the construction and publication of maps for use of the War Department and the Army, $50,000 will be required.

For geographical surveys of the territory of the United States west of the one hundredth meridian, there will be required for field and office work, and for preparing, engraving, and printing of plates and atlas-sheets, $120,000.

OFFICE OF THE CHIEF OF ENGINEERS.

In the labors of the office the Chief of Engineers was assisted, on the 30th of June, by the following officers in charge of the several divisions:

FIRST AND SECOND DIVISIONS.—*Fortifications, battalion, and engineer depot, lands, armaments, personnel, &c.*, Lieut. Col. Thos. L. Casey, in addition to his other duties; and Maj. W. J. Twining.

THIRD DIVISION.—*River and harbor improvements, &c.*, Maj. John G. Parke.

FOURTH AND FIFTH DIVISIONS.—*Property accounts, estimates, funds, survey of the lakes and the Mississippi River, explorations, maps, instruments, &c.*, Maj. George H. Elliot.

Very respectfully, your obedient servant,

H. G. WRIGHT,
Acting Chief of Engineers.

Hon. GEORGE W. MCCRARY,
Secretary of War.

STATEMENT SHOWING RANK AND DUTIES OF OFFICERS OF THE C OF ENGINEERS DURING THE FISCAL YEAR ENDING JUNE 30, 187

RANK AND NAME.	DUTIES.
BRIGADIER-GENERAL AND CHIEF OF ENGINEERS.	
Andrew A. Humphreys.. *Bvt. Major-General.*	Commanding Corps of Engineers. Member of Comm to examine into canal routes across the Isthmus co ing North and South America. Member of Board f survey of the harbor of Baltimore City and ad waters. Member of Joint Commission to supervi construction of the Washington Monument. Mem Advisory Board to Harbor Commissioners State of chusetts. Member of Board to determine pier and head lines of New York Harbor along Staten Island Member of Commission to examine into the mat contracts between the United States and the Water Power Company. To coöperate with the a ities of the State of New York in examining and de upon exterior pier and bulkhead lines on Hudson from State dam at Troy to the city of Hudson.
COLONELS.	
John G. Barnard..... *Bvt. Major-General.*	Member of Board of Engineers for Fortifications. M of Lighthouse Board. On special duty connected examination of works at South Pass of the Miss River. Member of Commission to select site f Naval Observatory.
Henry W. Benham..... *Bvt. Major-General.*	In charge of construction of forts Winthrop, Indepen and Warren, and work on Long Island Head, Mass. Montgomery, Columbus, Castle Williams, South B Governor's Island, Wood, Hamilton, and additions teries, and Mortar Battery at Fort Hamilton, N. Y fort at Sandy Hook, N. J. Member of Board of Offic the examination of candidates for promotion in the of Engineers.
John N. Macomb	In charge of improvement of the upper Mississipp Illinois rivers; and Des Moines and Rock Island of the Mississippi River, harbors of Fort Madison lington, and Dubuque, Iowa; the survey for the im ment of that portion of the "*Mississippi route*" desig by the Senate Select Committee on Transportation to Seaboard, as improvements upon a system to b vided so as to give from 4½ to 6 feet depth of wa lowest stages from Falls of St. Anthony to Alton. ber of Board of Engineers to report upon condit channel-way of the river opposite La Crosse, Wi charge of construction of forts Delaware, Del. Mifflin, Pa., battery at Finn's Point, N. J., and opposite Fort Delaware, and pier at Lewes, Del.; improvements at New Castle and Wilmington, Del., ter, Pa., and on Delaware River and Bay; improv of the Shrewsbury and Salem rivers and Cohansey N. J., Delaware and Broadkiln rivers, Del., and S kill River, Pa.
James H. Simpson ..... *Brt. Brig. General.*	In charge of improvement of Mississippi River betwe mouths of the Illinois and Ohio rivers, and Osage in Missouri and Kansas. Member of Board of Engin examine and report upon the most advisable meas preserving the water-front of Vicksburg. Mem Board of Officers to consider and report upon proj bridge across the Ohio River at Beaver, Pa. Mem

ent showing rank and duties of officers of Corps of Engineers—Con'd.

K AND NAME.	DUTIES.
OLONELS. ontinued.)	Board of Survey to examine into and report fully upon all facts connected with loss of the dredge-boat McAllester. Member of Board of Officers to consider and report upon plan and location of bridge proposed to be erected over Mississippi River at or near Glasgow, Mo.
Woodruff..... *t. Brig. General.*	On detached service. Engineer 3d Lighthouse District.
3. Tower..... *t. Maj. General.*	Member of Board of Engineers for Fortifications. Member of Board of Engineers to consider questions relating to improvement of Galveston Harbor and entrance. To confer with Assistant Treasurer at New York City for examinatoin of subtreasury building in that city and report what steps should be taken for its security and defense. Member of Board of Officers for the examination of candidates for promotion in the Corps of Engineers. On special duty to examine claim of H. S. Dale for compensation for work done in construction of Harbor of Refuge on Lake Huron, Mich. Member of general court-martial to meet at Buffalo, N. Y., January 15, 1878, for the trial of Lieutenant-Colonel *Blunt*. Member of Board of Engineers on improvement of channel into Charleston Harbor, S. C.
ANT-COLONELS.	
. Wright..... *. Maj. General.*	Member of Board of Engineers for Fortifications. Member of Commission on repavement of Pennsylvania Avenue, Washington, D. C. Member of Commission to examine into the matter of contracts between the United States and the Moline Water Power Company. Member of Board of Engineers to consider questions relating to improvement of Galveston Harbor and entrance. Member of Court of Inquiry to investigate all facts in connection with the administration of Lieutenant-Colonel *Blunt* on public works under his charge. On special duty connected with examination of South Pass of the Mississippi River. Member of Board of Engineers to report upon plan of a lock and gate proposed to be substituted by Major *Merrill* for the lock and gate heretofore approved in connection with the construction of first movable dams on the Ohio River. Member of Board of Engineers on improvement of Charleston Harbor, S. C.
ton..... *. Maj. General.*	In charge of manufacture and supply of mastic; improvement of the Hudson River, Harlem River, Echo Harbor, and East Chester Creek, N. Y., Otter Creek, Vt., Passaic and Raritan rivers, N. J.; removal of obstructions in the East River, including Hell Gate, N. Y.; improvement of channel between Staten Island and New Jersey; harbor improvements at Burlington and Swanton, Vt., Rondout, Port Chester, and Plattsburgh, N. Y. The survey of so much of the 3d subdivision of the "*Northern route*" designated by the Senate Select Committee on Transportation Routes to Seaboard, as extends from Troy, on the Hudson River, to New York City. To coöperate with the authorities of the State of New York in examining and deciding upon exterior pier and bulkhead lines on Hudson River from State dam at Troy to the city of Hudson. Member of Board of Engineers to consider questions relating to improvement of Galveston Harbor and entrance. Member of Court of Inquiry to investigate all facts in connection with the administration of Lieutenant-Colonel *Blunt* of public works under his charge. Member of Board of Engineers on improvement of channel into Charleston Harbor, S. C.

Statement showing rank and duties of officers of Corps of Engineers—Con'd.

RANK AND NAME.	DUTIES.
LIEUTENANT-COLONELS. (continued.)	
George Thom..... *Brt. Brig. General.*	In charge of improvement of rivers St. Croix, Machias, Penobscot, Kennebec, Kennebunk, Me., Cocheco, N. H., and Merrimac, Mass.; of harbors of Camden, Gut opposite Bath, Portland, Richmond's Island, Belfast, Me., Gloucester, Salem, Boston, Plymouth, and Provincetown, Mass. Member of general court-martial to meet in Buffalo, N. Y., June 15, 1878, for the trial of Lieutenant-Colonel *Blunt.*
John D. Kurtz..... *Brt. Colonel.*	In charge of construction of forts Delaware, Del., and Mifflin, Pa., battery at Finn's Point, N. J., and work opposite Fort Delaware, piers at New Castle and Lewes, Del.; harbor improvements at Wilmington, Del., and on Delaware River and Bay; improvement of the Shrewsbury River and Cohansey Creek, N. J., Delaware and Broadkiln rivers, Del., and Schuylkill River, Pa. Member of Board to examine and report upon the foundation of the Washington Monument. Died October 16, 1877.
Barton S. Alexander .... *Brt. Brig. General.*	Senior Engineer charged with general supervision and inspection of all matters under the command of the Chief of Engineers within the Pacific territory. Member of Board of Engineers for the Pacific Coast.
William F. Raynolds.... *Brt. Brig. General.*	On detached service. Engineer 4th Lighthouse District.
Charles S. Stewart.....	In charge of construction of fortifications at Fort Point, Point San José and Angel Island, San Francisco, and at San Diego, Cal., and improvement of San Diego Harbor and San Joaquin River, Cal. Member of Board of Engineers for the Pacific Coast.
Charles E. Blunt ..... *Brt. Colonel.*	In charge of improvement of harbors of Rocky River, Cleveland, Grand River, Ashtabula, Conneaut, Erie, Dunkirk, and Buffalo, on Lake Erie; and construction of Fort Porter, N. Y., and of Fort Wayne, Mich.
James C. Duane ..... *Brt. Brig. General.*	In charge of construction of forts Gorges, Preble, Scammel, Popham, Knox, and battery at Portland Head, Me., and forts Constitution and McClary, and batteries on Jerry's Point and Gerrish's Island, Portsmouth Harbor, N. H. Engineer 1st and 2d Lighthouse Districts. Member of Board to examine and report upon the foundation of the Washington Monument.
Robert S. Williamson...	On detached service. Engineer 12th Lighthouse District. Member of Board of Engineers for the Pacific Coast.
Quincy A. Gillmore ..... *Brt. Major-General.*	In charge of construction of forts Wadsworth, Tompkins, and its batteries, N. Y., Macon and Caswell, N. C., Moultrie, Sumter, Johnson, and Castle Pinckney, S. C., Jackson and Pulaski, Ga., Clinch and Marion, Fla., and temporary charge of forts Monroe and Wool, Va.; improvement of the bar at the mouth of St. John's River, and of the inside passage between St. John's River and Nassau Inlet, Fla., Charleston Harbor, S. C., Savannah River and Harbor, and harbor of Darien, Ga. Member of Board to test the strength and value of all kinds of iron, steel, and other metals submitted to it. Member of Commission on repavement of Pennsylvania Avenue, Washington, D. C. Member of Board of Engineers on improvement of Charleston Harbor, S. C. Member of Board to examine and report upon the foundation of the Washington Monument. Member of Board of Officers for the examination of candidates for promotion in the Corps of Engineers.

ment showing rank and duties of officers of Corps of Engineers—Con'd.

NK AND NAME.	DUTIES.
NANT-COLONELS. continued.)	
incoln Casey .... *rt. Colonel.*	In charge of the 1st and 2d Divisions, Office of the Chief of Engineers; of Public Buildings and Grounds and certain Public Works in the District of Columbia; of work upon the building for the State, War, and Navy Departments, of the Washington Aqueduct, and the construction of the Washington National Monument. Member of Board to advise upon the ventilation of the Hall of the House of Representatives.
el Michler ..... *t. Brig. General.*	In charge of improvement of harbors of Port Clinton, Monroe, Toledo, Sandusky City, Huron, Vermillion, and Black River, on Lake Erie.
MAJORS.	
Parke..... *t. Major-General.*	In charge of the 3d Division, Office of the Chief of Engineers. Member of Board of Officers to prescribe rules and regulations for contracts under the War Department.
ew K. Warren .. *t. Major-General.*	In charge of construction of defenses of New Bedford Harbor, Mass., Narragansett Bay, R. I.; improvement of harbors of Wareham, Hyannis, Fall River, and New Bedford, Mass., Wickford and Newport, R. I.; improvement of rivers Taunton, Mass., Pawtucket and Providence, R. I., and Pawcatuck, R. I., and Conn., and Connecticut, Conn.; Narragansett Bay, R. I., and Little Narragansett Bay, R. I., and Conn.; construction of Breakwater at Block Island, R. I.; examining and reporting upon constructing railroad bridges across the Mississippi River between St. Paul and St. Louis, &c. Member of Board of Officers to consider and report upon plan and location for bridge proposed to be built across the Ohio River by the Commonwealth Bridge Company.
l. Mendell..... *t. Colonel.*	In charge of construction of fort on Alcatraz Island, and of defenses at Lime Point, San Francisco Bay; Breakwater at Wilmington Harbor, Cal.; improvement of Oakland Harbor, and Sacramento and Feather rivers, Cal. Member of Board of Engineers for the Pacific Coast. Member of Advisory Board of Commissioners on the Harbor Lines of San Francisco.
. Abbot ..... *t. Brig. General.*	Commanding Engineer Depot and Post of Willets Point, and Battalion of Engineers. In charge of construction of Fort Schuyler and fort at Willets Point, N. Y., and of experiments with torpedoes. On service with Battalion in Baltimore, Md., Philadelphia and Easton, Pa., during the railroad riots of 1877. Member of Commission to examine into the matter of contracts between the United States and the Moline Water Power Company.
P. Craighill .... *t. Lieut. Colonel.*	In charge of construction of defenses of Baltimore, Md., and Washington, D. C.; improvement of Chester, Wicomico, Elk, and Pocomoke rivers, Md., James and Appomattox rivers, Va., Great Kanawha, New, and Elk rivers, West Va., and Cape Fear River, N. C., and of the harbor of Baltimore, and inner harbor at Cambridge, Md. Member of Board for survey of the harbor of Baltimore City and adjacent waters. Member of Board of Engineers to report upon plan of a lock and gate proposed to be substituted by Major *Merrill* for the lock and gate heretofore approved in connection with the construction of first movable dams on the Ohio River. On duty in Europe for the purpose of gathering professional information respecting the construction of movable dams and similar structures.

Statement showing rank and duties of officers of Corps of Engineers—

RANK AND NAME.	DUTIES.
MAJORS. (continued.)	
Cyrus B. Comstock..... *Brt. Brig. General.*	In charge of the survey of Northern and Northwestei and survey of the Mississippi River. Detailed t upon the depth and width of a channel secured ar tained by jetties constructed by James B. Ead mouth of the Mississippi River.
Godfrey Weitzel..... *Brt. Major-General.*	In charge of improvement of the falls of the Ohi and Louisville and Portland Canal; of St. Mar Canal, St. Mary's, Detroit, and Sebawaing riven of harbors of Au Sable River, St. Clair River a of Black River, and Thunder Bay; Harbor of R Lake Huron. Engineer 11th Lighthouse District ber of Board of Officers to consider and report upo for a bridge across the Ohio River at Beaver, Pa ber of Board of Engineers to examine and repc condition of channel-way of the river opposite La Wis. Member of Board of Officers to consider an upon plan and location for bridge proposed to across the Ohio River by the Commonwealth Brid pany. Member of Board of Engineers to report u of a lock and gate proposed to be substituted b *Merrill* for the lock and gate heretofore approve nection with the construction of first movable dan Ohio River.
Orlando M. Poe..... *Brt. Brig. General.*	On detached service. Aide-de-camp on the perso of the General of the Army with the rank of Member of Lighthouse Board. Member of Comm Engineers to devise means of permanent protectior destruction of wharves in harbor of New Orlean croachments of the Mississippi River. Member c of Engineers to report upon plan of a lock and g posed to be substituted by Major *Merrill* for the gate heretofore approved in connection with t struction of first movable dams on the Ohio Rive
David C. Houston..... *Brt. Colonel.*	In charge of harbor improvements at Milwaukee, and Kenosha; improvement of the Fox and W rivers.
George H. Elliot.....	In charge of the 4th and 5th Divisions, Office of t of Engineers.
Henry M. Robert.....	In charge of harbor improvements at Ontonago Harbor, Marquette, Menomonee, Green Bay, A Two Rivers, Manitowoc, Sheboygan, Port Wash and Harbor of Refuge at entrance of Sturgeon Ba
William E. Merrill..... *Brt. Colonel.*	In charge of improvement of the Ohio and Mono rivers; the Little Kanawha and Guyandotte ri Va., and Big Sandy River, Ky.; construction of of Refuge at or near Cincinnati. Engineer 14th house District. Member of Board of Officers to and report upon project for a bridge across the Oh at Beaver, Pa. Member of Board of Engineers to and report upon condition of channel-way of t opposite La Crosse, Wis. Member of Board of O consider a bridge proposed to be built across t River by the Commonwealth Bridge Company. of Board of Engineers to report upon plan of a l gate proposed to be substituted by Major *Merril* lock and gate heretofore approved in connection construction of first movable dams on the Ohi On duty in Europe for the purpose of gathering sional information respecting movable dams and structures.

'ement showing rank and duties of officers of Corps of Engineers—Con'd.

'ANK AND NAME.	DUTIES.
MAJORS. (continued.)	
ɪr McFarland.....	In charge of improvement of harbors of Rocky River, Cleveland, Fairport, Ashtabula, Conneaut, Erie, Dunkirk, and Buffalo, on Lake Erie; and construction of Fort Porter, N. Y., Fort Wayne, Mich., and forts Ontario and Niagara, N. Y.; of harbor improvements at Olcott, Oak Orchard, Charlotte, Pultneyville, Big Sodus, Little Sodus, Oswego, Ogdensburg, Wilson, and Waddington, N. Y. Engineer 10th Lighthouse District.
ɪ E. Babcock ..... *Brt. Brig. General.*	On detached service. Engineer 5th Lighthouse District.
f. Wilson..... *Brt. Colonel.*	In charge of works for defense of the mouth of the Columbia River, and improvement of the Willamette, Columbia, and Snake rivers; construction of canal around the Cascades of the Columbia River. Engineer 13th Lighthouse District.
in Harwood..... *Brt. Lieut. Colonel.*	In charge of St. Clair Flats Canal, and improvement of Saginaw River, and Cheboygan Harbor, Mich.; of harbors of Au Sable River, St. Clair River at mouth of Black River, and Thunder Bay.
'. Barlow..... *Brt. Lieut. Colonel.*	In charge of forts Griswold and Hale, and the construction of Fort Trumbull, Conn.; improvement of harbors of Stonington, New Haven, Bridgeport, Milford, Southport and Norwalk, Conn., and Port Jefferson, N. Y.; improvement of Housatonic and Thames rivers, Conn.
. Hains ..... *'rt. Lieut. Colonel.*	On detached service. Engineer Secretary to Lighthouse Board.
U. Farquhar.... *:t. Lieut. Colonel.*	In charge of harbor improvements at Superior City, Superior Bay, and Duluth; improvement of Falls of St. Anthony, and of the Mississippi River, above the Falls of St. Anthony; improvement of Chippewa and Minnesota rivers and the Red River of the North; construction of Meeker's Island lock and dam. In charge of harbor improvements of the Mississippi River, from St. Paul to the mouth of the Illinois River; of the upper Mississippi River and Rock Island Rapids of the Mississippi River; harbors of Fort Madison, Burlington, and Dubuque, Iowa, Galena River and Harbor, Ill.; the survey for the improvement of that portion of the "*Mississippi route*" designated by the Senate Select Committee on Transportation Routes to Seaboard, as improvements upon a system to be provided so as to give from 4½ to 6 feet depth of water at lowest stages from Falls of St. Anthony to Alton; the protection of the piers of the Rock Island Government Bridge.
. Gillespie ..... *t. Lieut. Colonel.*	On leave of absence in Europe.
ɪ. Suter.....	In charge of improvement of the Mississippi, Missouri, Arkansas, White, and St. Francis rivers—removal of snags, &c. Improvement of the Missouri River at the following localities: St. Joseph, Council Bluffs, Omaha, Nebraska City, Atchison, Eastport, Fort Leavenworth, and Sioux City. Survey of the Missouri River from its mouth to Sioux City. Engineer 15th Lighthouse District. Member of Board of Engineers to examine and report upon the most advisable measure for preserving the water-front of Vicksburg. Member of Board of Officers to consider and report upon plan and location of bridge proposed to be erected over the Missouri River at or near Glasgow, Mo.

Statement showing rank and duties of officers of Corps of Engineers—Con'd.

Rank and Name.	Duties.
MAJORS. (continued.)	
Jared A. Smith.....	In charge of the improvement of the Wabash River and harbors of Michigan City and New Buffalo.
Samuel M. Mansfield.... *Brt. Lieut. Colonel.*	In charge of harbor improvements at Charlevoix, Frankfort, Manistee, Ludington, Pentwater, White River, Muskegon, Grand Haven, Black Lake, Saugatuck, South Haven and St. Joseph, on Lake Michigan.
William J. Twining	On temporary duty in the Office of the Chief of Engineers.
CAPTAINS.	
William R. King..... *Brt. Major.*	In charge of improvement of the Tennessee River, Cumberland River above and below Nashville, Tenn., and Hiawassee River, Tenn.; Oostenaula, Coosawattee, Etowah, Oconee, and Ocmulgee rivers, Ga., and Coosa River, Ga. and Ala.
Wm. H. H. Benyaurd... *Brt. Major.*	In charge of improvement of the L'Anguille River, Ark., and the Ouachita River in La. and Ark., Yazoo River in Miss., and Cypress Bayou, Tex.; of water-gauges on the Mississippi River and its principal tributaries; improvement of mouth of the Red River, La., and harbors of Memphis, Tenn., and Vicksburg, Miss., and the Mississippi River at those points; removal of raft, snags, and other obstructions from Red River, and closing Tone's Bayou. Member of Board of Engineers to examine and report upon the most advisable measure for preserving the water-front of Vicksburg. Member of Commission of Engineers to devise means of permanent protection against destruction of wharves in harbor of New Orleans by encroachments of the Mississippi River.
Charles W. Howell..... *Brt. Major.*	In charge of construction of forts Pike, Macomb, Tower Dupré, Battery Bienvenue, Tower at Proctorsville, and forts Jackson, St. Philip, and Livingston; improvement of the mouth of the Mississippi River at Southwest Pass; of New Orleans and Galveston harbors, Sabine Pass and Red Fish Bar in Galveston Bay; improvement of ship-channel San Jacinto River to Bolivar Channel, Galveston Bay, Texas; improvement of Pass Cavallo, Texas. Removal of wrecks and other obstructions to navigation at Brazos Santiago, Tex., and in Bayou La Fourche, La.; improvement of the narrows above Orange on Sabine River, Tex., and deepening the channel at mouth of said river; deepening channel at mouth of Trinity River, Tex., and removal of obstructions to Liberty; deepening of channel at mouth of Neches River, Tex., and removal of obstructions to Beaumont. Member of Board of Engineers to consider questions relating to improvement of Galveston Harbor and entrance. Member of Commission of Engineers to devise means of permanent protection against destruction of wharves in harbor of New Orleans by encroachments of the Mississippi River.
Garret J. Lydecker	Engineer Officer, Mil. Div. of the Missouri. In charge of the construction of the harbors of Chicago, Calumet, Michigan City, and New Buffalo, and the improvement of the Illinois River.
Arthur H. Burnham.....	On duty under immediate orders of Colonel *Benham*. Died September 12, 1877.
Amos Stickney..... *Brt. Major.*	On duty under immediate orders of Colonel *Macomb*. In charge of the Des Moines Rapids Canal and the improvement of the Des Moines Rapids of the Mississippi River.

atement showing rank and duties of officers of Corps of Engineers—Con'd.

Rank and Name.	Duties.
CAPTAINS. (continued.)	
ıes W. Cuyler	On duty under the immediate orders of Major *Craighill*. In temporary charge of the upper New River, W. Va.
ıander Mackenzie ...	On duty under immediate orders of Major *Weitzel*. In temporary charge of improvement of the falls of the Ohio River and Louisville and Portland Canal; of St. Mary's Falls Canal, St. Mary's, St. Clair, Detroit, and Sebawaing rivers, Mich.; Harbor of Refuge on Lake Huron. Engineer 11th Lighthouse District.
ıld H. Ernst.....	Commanding Company E, Battalion of Engineers. On duty at the Military Academy as instructor of Practical Military Engineering, Military Signaling, and Telegraphy.
ı P. Heap	On duty under immediate orders of Major *Warren*.
ım Ludlow..... *Brt. Lieut. Colonel.*	On duty under immediate orders of Lieutenant-Colonel *Kurtz*. In temporary charge of construction of forts Delaware, Del., and Mifflin, Pa., battery at Finn's Point, N. J., and work opposite Fort Delaware, piers at New Castle and Lewes, Del.; harbor improvements at Wilmington, Del., and on Delaware River and Bay; improvement of the Shrewsbury River and Cohansey Creek, N. J., Delaware and Broadkiln rivers, Del., and Schuylkill River, Pa. On duty under immediate orders of Colonel *Macomb*.
ıs B. Phillips.....	On duty under immediate orders of Major *Craighill*. In temporary charge of construction of defenses of Baltimore, Md., and Washington, D. C.; improvement of Chester, Wicomico, Elk, and Pocomoke rivers, Md., James and Appomattox rivers, Va., Great Kanawha, New, and Elk rivers, W. Va., and Cape Fear River, N. C., and of the harbor of Baltimore, and inner harbor at Cambridge, Md. Member of Advisory Board to State Harbor Commission of Norfolk and Portsmouth.
ım A. Jones	On detached service. Engineer 6th Lighthouse District.
w N. Damrell..... *Brt. Major.*	In charge of construction of defenses of Mobile and Pensacola, and fort on Ship Island, Miss.; improvement of harbors of Pensacola and Cedar Keys, Fla., and Mobile, Ala.; of Chattahoochee and Flint rivers, Ga., Alabama and Pascagoula rivers, Miss., Appalachicola River, Fla., and Warrior and Tombigbee rivers, in Ala. and Miss.; removal of obstructions in the Choctawhatchie River, Ala. and Fla. Engineer 8th Lighthouse District.
ıs J. Allen ..... *Brt. Major.*	On duty under immediate orders of Colonel *Simpson*. Member of Board of Officers to consider and report upon plan and location of bridge proposed to be erected over the Missouri River at or near Glasgow, Mo.
ıs W. Raymond ...	On detached service. On duty at the Military Academy.
C. Overman	On duty under immediate orders of Captain *King*.
ıder M. Miller.....	Commanding Company B, Battalion of Engineers; on service with Battalion in Baltimore, Md., Philadelphia and Easton, Pa., during the railroad riots in 1877. Member of general court-martial to meet at Easton, Pa., August 10, 1877. Member of general court-martial to meet at Willets Point, New York Harbor, May 31, 1878.
R. Brown	Temporarily detailed to report upon the depth and width of a channel secured and maintained by jetties constructed by James B. Eads at the mouth of the Mississippi River. On duty under the immediate orders of Major *Comstock in connection with the jetties constructed by James B. Eads at the mouth of the* Mississippi River.

Statement showing rank and duties of officers of Corps of Engineers—Con'd

RANK AND NAME.	DUTIES.
CAPTAINS. (continued.)	
Milton B. Adams.....	On duty under immediate orders of Lieutenant-Colonel *Blunt*. On duty under immediate orders of Major *McFarland*.
Wm. R. Livermore.....	Commanding Company C, Battalion of Engineers; on service with Battalion in Baltimore, Md., Philadelphia and Easton, Pa., during the railroad riots of 1877.
William H. Heuer.....	In charge of construction of forts Jefferson and Taylor, Fla. Engineer 7th Lighthouse District.
William S. Stanton	On detached service. Engineer Officer, Department of the Platte.
A. Nisbet Lee.....	On duty under immediate orders of Major *Weitzel*. On duty under immediate orders of Captain *Mackenzie*.
Thomas H. Handbury...	Commanding Company A, Battalion of Engineers; on service with Battalion in Baltimore, Md., Philadelphia and Easton, Pa., during the railroad riots of 1877. Member of general court-martial to meet at Willets Point, New York Harbor, May 31, 1878.
James C. Post	On duty under immediate orders of Lieutenant-Colonel *Gillmore*.
James F. Gregory.....	On detached service. Engineer Officer, Dept. of Texas. Member of general court-martial to meet at Fort Clark, Tex., October 15, 1877. Commanding Company C, Battalion of Engineers.
Henry M. Adams	In temporary charge of the survey of Northern and Northwestern Lakes and survey of the Mississippi River. On duty under immediate orders of Major *Comstock*.
James Mercur	In temporary charge of construction of forts Montgomery, Columbus, Castle Williams, South Battery Governor's Island, Wood, Hamilton, and additional batteries, Mortar Battery at Fort Hamilton, and fort at Sandy Hook. In temporary charge of manufacture and supply of mastic; improvement of the Hudson River, Harlem River, and East Chester Creek, N. Y., Otter Creek, Vt., and Passaic River, N. J.; removal of obstructions in the East River, including Hell Gate, N. Y.; improvement of channel between Staten Island and New Jersey; harbor improvements at Burlington and Swanton, Vt., Rondout, Portchester, and Plattsburgh, N. Y.; the survey of so much of the 3d subdivision of the "*Northern route*" designated by the Senate Select Committee on Transportation Routes to Seaboard, as extends from Troy, on the Hudson River, to New York City, under immediate orders of Lieutenant-Colonel *Newton*. Recorder of Board of Engineers on improvement of Charleston Harbor, S. C.
Chas. E. L. B. Davis....	On duty under immediate orders of Captain *Howell*.
Benjamin D. Greene	Adjutant Battalion of Engineers and Post of Willets Point. Post Treasurer and Signal Officer.
FIRST LIEUTENANTS.	
George M. Wheeler	In charge of Geographical Surveys of the territory west of the 100th meridian.
James B. Quinn	Q. M. Battalion of Engineers. A. A. Q. M., A. C. S., and Recruiting Officer Post of Willets Point. On service with Battalion in Baltimore, Md., Philadelphia and Easton, Pa., during the railroad riots of 1877. Member of general court-martial to meet at Willets Point, New York Harbor, May 31, 1878.

tement showing rank and duties of officers of Corps of Engineers—Con'd.

RANK AND NAME.	DUTIES.
RST LIEUTENANTS. (continued.)	
el W. Lockwood ...	On duty under immediate orders of Captain *H. M. Adams.* On duty under immediate orders of Major *Comstock.*
st H. Ruffner	On detached service. Engineer Officer, Department of the Missouri. Member of general court-martial to meet at Leavenworth Military Prison, Kan., November 2, 1877. Member of general court-martial to meet at Fort Lyon, Col.
C. Mallery.....	On detached service. Engineer Officer, Mil. Div. of Pacific and Department of California. On temporary duty with the Commissioner of Education in connection with the Paris Exposition, &c. On duty with Board of Commissioners to determine the Boundary Line between the States of Virginia and West Virginia.
n B. Sears.....	On detached service. On duty at the Military Academy.
s Turtle	On duty under immediate orders of Major *Craighill.* On duty under immediate orders of Captain *Phillips.*
d Maguire	On detached service. Engineer Officer, Department of Dakota. In charge of the improvement of the Missouri River above the mouth of the Yellowstone under the direction of the Chief of Engineers, and the survey of the Yellowstone River.
ck A. Mahan....	On duty under immediate orders of Major *Merrill.* In temporary charge of improvement of the Ohio and Monongahela rivers; the Little Kanawha and Guyandotte rivers, W. Va., and Big Sandy River, Ky., construction of Harbor of Refuge, at or near Cincinnati. Engineer 14th Lighthouse District. Recorder of Board of Engineers to examine and report upon plan of a lock and gate proposed to be substituted by Major *Merrill* for the lock and gate heretofore approved in connection with the construction of first movable dams on the Ohio River.
F. Powell.....	On duty under immediate orders of Captain *H. M. Adams.* On duty under immediate orders of Major *Comstock.*
k A. Hinman...	On duty under immediate orders of Major *Houston.*
H. Payson	On duty under immediate orders of Lieutenant-Colonel *Stewart,* and of the Board of Engineers for the Pacific Coast.
D. Knight.....	On detached service. On duty at the Military Academy.
L. Hoxie.....	On detached service. Chief Engineer of the District of Columbia under the direction of the Board of Commissioners.
N. Bass.....	On detached service. On duty at the Military Academy. Resigned May 2, 1878.
L. Marshall....	On duty under immediate orders of Captain *King.*
H. Willard.....	On duty under immediate orders of Captain *Mercur.* On duty under immediate orders of Lieutenant-Colonel *Newton.* Recorder of Board appointed to coöperate with the authorities of the State of New York in examining and deciding upon exterior pier and bulkhead lines on Hudson River from State dam at Troy to the city of Hudson.
gland.....	On duty under immediate orders of Lieutenant *Wheeler.*
E. Tillman.....	On duty under immediate orders of Lieutenant *Wheeler.*
I. Price	On duty under immediate orders of Captain *H. M. Adams.* On duty under immediate orders of Major *Comstock.*

Statement showing rank and duties of officers of Corps of Engineers—

RANK AND NAME.	DUTIES.
FIRST LIEUTENANTS. (continued.)	
Francis V. Greene.....	On detached service. On duty under the Depar State as Military Attaché to the U. S. Legatio Petersburg.
Carl F. Palfrey	On detached service. On duty at the Military Aca
William H. Bixby	On detached service. On duty at the Military Aca
Henry S. Taber.....	On duty at the Military Academy, and with Com Battalion of Engineers.
William T. Rossell.....	On detached service. On duty at the Military Aca
Thomas N. Bailey	On detached service. On duty at the Military Aca
Thos. W. Symons	On duty under immediate orders of Lieutenant *Wh*
SECOND LIEUTENANTS.	
Smith S. Leach.....	On duty with Company C, Battalion of Engineers; ice with Battalion in Baltimore, Md., Philadelp Easton, Pa., during the railroad riots of 1877. advocate of general court-martial to meet at Eas August 10, 1877.
Dan C. Kingman.....	On duty with Company C, Battalion of Engineers; o with Battalion in Baltimore, Md., Philadelphia a on, Pa., during the railroad riots of 1877. On te duty under immediate orders of Lieutenant-Colo *more* in connection with the Washington Monum duty with Company A, Battalion of Engineers.
Eugene Griffin	On duty with Company B, Battalion of Engineers; ice with Battalion in Baltimore, Md., Philadelp Easton, Pa., during the railroad riots of 1877. under immediate orders of Lieutenant *Wheeler.* porary duty with Battalion of Engineers.
Willard Young	On duty with Company A, Battalion of Engineers; ice with Battalion in Baltimore, Md., Philadelp Easton, Pa., during the railroad riots of 1877. under immediate orders of Lieutenant *Wheeler.*
William M. Black.....	On duty at U. S. Military Academy. On duty wi pany C, Battalion of Engineers. Member of gener martial to meet at Willets Point, New York Harb 31, 1878.
Walter L. Fisk	On duty at U. S. Military Academy. On duty wi pany B, Battalion of Engineers. Member of gener martial to meet at Willets Point, New York Harb 31, 1878.
Solomon W. Roessler....	On duty with Company A, Battalion of Engineers. advocate of general court-martial to meet at Point, New York Harbor, May 31, 1878.
U. S. CIVIL ENGINEERS.	
Clarence King	In charge of Geological Exploration of 40th Paralle
S. T. Abert	In charge of improvement of Occoquan, Rappal Elizabeth, Nansemond, Black Water, Hampton, an ahominy rivers, Va., Roanoke, Pamplico, Per and French Broad rivers, N. C.; of Aquia, Accot Nomini creeks, Va.; of the harbors of Washing Georgetown, D. C., Norfolk, Va., and harbor o Bay, Leonardtown, Md.
M. Meigs	On duty under immediate orders of Colonel *Macc* duty under immediate orders of Major *Farquhar.*

LAWS

AFFECTING THE

CORPS OF ENGINEERS.

FORTY-FIFTH CONGRESS, FIRST AND SECOND SESSIONS.

1877–'78.

LAWS

AFFECTING

THE CORPS OF ENGINEERS.

FORTY-FIFTH CONGRESS, FIRST AND SECOND SESSIONS, 1877-'78.

CHAP. 1.—An act making appropriations for the support of the Army for the fiscal year ending June 30, 1878, and for other purposes. Nov. 21, 1877.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the following sums be, and the same are hereby, appropriated, out of any money in the Treasury not otherwise appropriated, for the support of the Army, for the year ending June thirtieth, eighteen hundred and seventy-eight, as follows: Appropriations. Military service.

* * * * * * *

ENGINEER DEPARTMENT.—For engineer depot at Willets Point, New York, namely: For purchase of engineering materials to continue the present course of instruction of the engineer battalion in field engineering, one thousand dollars. Engineer Department. School of battalion.

For incidental expenses of the depot, remodeling ponton-trains, repairing instruments, fuel, forage, stationery, chemicals, extra-duty pay, ordinary repairs, one thousand five hundred dollars. Incidental expenses.

* * * * * * *

Approved, November 21, 1877.

[No. 2] Joint resolution fixing a site for the equestrian statue of General Greene. Nov. 23, 1877.

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That the statue of Major-General Nathanael Greene, ordered by Congress, be erected at the intersection of Maryland and Massachusetts avenues. Site for statue of General Greene.

Approved, November 23, 1877.

CHAP. 3.—An act to provide for deficiencies in the appropriations for the service of the government for the fiscal year ending June 30, 1878, and for prior years, and for other purposes. Dec. 15, 1877.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the following sums be, and the same are hereby, appropriated, out of any money in the Treasury not otherwise appropriated, except as differently specified, for the objects hereinafter expressed, namely: Deficiency appropriations.

* * * * * * *

For adapting the ponds in Monument lot in the city of Washington to the culture of carp for distribution throughout the United States (the use of which lot for the purpose in question being hereby granted to the United States Fish Commission), the work to be done by the engineer in charge of public buildings and grounds, according to the plans of the United States Fish Commission, five thousand dollars, to be available immediately. Cultivation of carp. Use of lot for.

* * * * * * *

That the Secretary of War is authorized to rent offices required for the construction of the State, War, and Navy Department building, and public buildings and grounds, at an aggregate rental not to exceed two Rent of buildings authorized.

thousand one hundred dollars per annum, until such offices can be supplied in buildings belonging to the government; and to pay for the rent of the building now occupied for said offices, from the first day of May, eighteen hundred and seventy-seven, out of any existing appropriations for the State, War, and Navy Department building, or public buildings and grounds.

MISCELLANEOUS.

* * * * * * *

State, War, and Navy Department building.

State, War, and Navy Department building: For continuation of the east wing of the building, one hundred and seventy-five thousand dollars; and for continuation of the north wing of the building, one hundred and fifty thousand dollars; in all, three hundred and twenty-five thousand dollars.

* * * * * * *

Approved, December 15, 1877.

Feb. 7, 1878.

CHAP. 13.—An act for the removal of obstructions from the Mississippi, Missouri, Arkansas, and Red Rivers and for the preservation of the public property.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the sum of forty thousand dollars be and the same is hereby appropriated out of any money in the Treasury not otherwise appropriated, to be expended under the direction of the War Department, for the removal of snags and other obstructions from the Mississippi, Missouri, and Arkansas Rivers, and for the preservation of the government vessels in that service.

Appropriations.

Removing obstructions from Mississippi and other rivers.

Opening navigation of Red River, La.

SEC. 2. That the sum of six thousand dollars be and the same is hereby appropriated out of any money in the Treasury not otherwise appropriated, to be expended under the direction of the War Department, for the purpose of opening the navigation of Red River above Shreveport in the State of Louisiana, and keeping said navigation open and free from rafts, and for the purpose of preserving the vessels and boats of the United States employed in that work.

SEC. 3. That this act take effect from the date of its passage.

To take effect.

Approved, February 7, 1878.

March 13, 1878.

CHAP. 32.—An act to authorize the construction of a bridge across the Missouri River at or near Glasgow, Missouri.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That any corporation existing, or which may be organized, under the laws of the State of Missouri, be, and is hereby, authorized to construct and maintain a bridge, and approaches thereto, over the Missouri River, at or near Glasgow, in the county of Howard, in said State. Said bridge shall be constructed to provide for the passage of railway-trains, and, at the option of the corporation by which it may be built, may be used for the passage of wagons and vehicles of all kinds, for the transit of animals, and for foot-passengers.

Railroad and wagon bridge may be built at Glasgow, Mo.

Post-route; rate payable by United States.

SEC. 2. That any bridge built under this act, and subject to its limitations, shall be a lawful structure, and shall be recognized and known as a post-route, upon which also no higher charge shall be made for the transmission over the same of the mails, the troops, and the munitions of war of the United States than the rate per mile paid for the transportation over the railroad or public highways leading to the said bridge; and it shall enjoy the rights and privileges of other post-roads in the United States.

How to be constructed.

SEC. 3. That if said bridge shall be made with unbroken and continuous spans, the spans thereof shall not be less than three hundred feet in length in the clear, and the main span shall be over the main channel of the river. The lowest part of the superstructure of said bridge shall be at least fifty feet above extreme high-water mark as understood

at the point of location, and the bridge shall be at right angles to, and its piers parallel with, the current of the river: *Provided*, That if the same shall be constructed as a draw-bridge, the draw or pivot shall be over the main channel of the river at an accessible navigable point, and the spans shall not be less than one hundred and sixty feet in length in the clear, and the piers of said bridge shall be parallel with, and the bridge itself at right angles to, the current of the river, and the spans shall not be less than ten feet above extreme high-water mark, as understood at the point of location, to the lowest part of the superstructure of said bridge: *Provided also*, That said draw shall be opened promptly, upon reasonable signal, for the passing of boats; and said company or corporation shall maintain at its own expense, from sunset till sunrise, such lights or other signals on said bridge as the Light-House Board shall prescribe. No bridge shall be erected or maintained under the authority of this act which shall at any time substantially or materially obstruct the free navigation of said river; and if any bridge erected under such authority shall, in the opinion of the Secretary of War, obstruct such navigation, he is hereby authorized to cause such change or alteration of said bridge to be made as will effectually obviate such obstruction; and all such alterations shall be made and all such obstructions be removed at the expense of the owner or owners of said bridge. And in case of any litigation arising from any obstruction or alleged obstruction to the free navigation of said river, caused or alleged to be caused by said bridge, the case may be brought in the district court of the United States of the State of Missouri, in which any portion of said obstruction or bridge may be located: *Provided further*, That nothing in this act shall be so construed as to repeal or modify any of the provisions of law now existing in reference to the protection of the navigation of rivers, or to exempt this bridge from the operation of the same.

Opening of draw; signals.

Obstruction of navigation.

Alterations.

Jurisdiction of courts.

Existing laws.

SEC. 4. That all railroad companies desiring the use of said bridge shall have and be entitled to equal rights and privileges relative to the passage of railway-trains over the same, and over the approaches thereto, upon payment of a reasonable compensation for such use; and in case the owner or owners of said bridge and the several railroad companies, or any one of them, desiring such use, shall fail to agree upon the sum or sums to be paid, and upon rules and conditions to which each shall conform in using said bridge, all matters at issue between them shall be decided by the Secretary of War, upon a hearing of the allegations and proofs of the parties.

Use of bridge.

SEC. 5. That any bridge authorized to be constructed under this act shall be built and located under and subject to such regulations for the security of navigation of said river as the Secretary of War shall prescribe; and, to secure that object, the said company or corporation shall submit to the Secretary of War, for his examination and approval, a design and drawings of the bridge, and a map of the location, giving, for the space of one mile above and one mile below the proposed location, the topography of the banks of the river, the shore-lines at high and low water, the direction and strength of the currents at all stages, and the soundings, accurately showing the bed of the stream, the location of any other bridge or bridges, and shall furnish such other information as may be required for a full and satisfactory understanding of the subject; and until the said plan and location of the bridge are approved by the Secretary of War, the bridge shall not be built; and should any change be made in the plan of said bridge during the progress of construction, such change shall be subject to the approval of the Secretary of War.

Regulations by Secretary of War.

Map and drawings.

Approval.

SEC. 6. That the right to alter, amend, or repeal this act is hereby expressly reserved.

Amendment and repeal.

Approved, March 13, 1878.

CHAP. 43.—An act making appropriations for fortifications and for other works of defense and for the armament thereof, for the fiscal year ending June 30, 1879, and for other purposes.

March 23, 1878.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the sum of one hundred thousand dollars be, and the same is hereby, appropriated, out of any money in the Treasury not otherwise appropriated, for the protection, preservation, and repair of fortifications and other works of defense, for the fiscal year ending June thirtieth, eighteen hundred and seventy-nine,

Appropriations.

Fortifications.

the same to be expended under the direction of the Secretary of War; also, the following for armament of fortifications, namely:

* * * * * * *

Torpedoes for harbor defenses.

For torpedoes for harbor defenses, and preservation of the same, and for torpedo experiments in their application to harbor and land defense, and for instruction of engineer battalion in their preparation and application, fifty thousand dollars: *Provided*, That the money herein appropriated for torpedoes shall only be used in the establishment and maintenance of torpedoes to be operated from shore-stations for the destruction of an enemy's vessel approaching the shore or entering the channel and fairways of harbors.

Proviso limiting use.

Approved, March 23, 1878.

April 10, 1878.

CHAP. 58.—An act to authorize the Secretary of War to prescribe rules and regulations to be observed in the preparation, submission, and opening of bids for contracts under the War Department.

Be it enacted by the Senate and House of Represenatives of the United States of America in Congress assembled, That the Secretary of War is hereby authorized to prescribe rules and regulations to be observed in the preparation and submission and opening of bids for contracts under the War Department; and he may require any bid to be accompanied by a bond in such penal sum as he may deem advisable, with good and sufficient security, conditioned that the bidder will enter into a contract agreeably to the terms of his bid, if the same be awarded to him within sixty days from the date of the opening of the bids, or otherwise pay the penalty. No bid shall be withdrawn by the bidder within the said period of sixty days.

Bids for contracts under War Department.

Approved, April 10, 1878.

April 20, 1878.

CHAP. 62.—An act to authorize the construction of a bridge abutment and approach within the Fort Riley military reservation.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Secretary of War be, and he is hereby, authorized to permit the county commissioners of Davis County, Kansas, in erecting a bridge across the Republican River, to construct one abutment of the same upon land included within the military reservation of Fort Riley, and also to permit the eastern approach to the same to be laid out across said reservation: *Provided*, That such bridge and the highway leading thereto shall always be open to government transportation free of charge, and that such point shall be selected for the construction of said abutment and approach as shall be mutually agreed upon by said county commissioners and the Secretary of War.

Bridge over Republican River; location of abutment and approach.

Use of by government.

Approved, April 20, 1878.

April 30, 1878.

CHAP. 75.—An act to provide for deficiencies in the appropriations for the service of the government for the fiscal year ending June 30, 1878, and for prior years, for subsistence of the Army, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the following sums be, and the same are hereby, appropriated, out of any money in the Treasury not otherwise appropriated, for the objects hereinafter expressed, namely:

Deficiency appropriations.

* * * * * * *

Carp in ponds in Monument lot.

To complete the work of adapting the ponds in the Monument lot in the city of Washington to the culture of carp for distribution throughout the United States, to be done by the engineer in charge of public buildings and grounds, according to the plans of the United States Fish Commission, two thousand two hundred dollars, or so much thereof as may be necessary; to be available immediately.

* * * * * * *

Des Moines Rapids Canal.

To pay the current expenses of operating the Des Moines Rapids Canal on the Upper Mississippi River until July first, eighteen hundred and seventy-eight, seven thousand five hundred dollars, or so much

thereof as may be necessary, the same to be expended under the direction of the Secretary of War.

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Approved, April 30, 1878.

CHAP. 95.—An act making an appropriation for pier-lights at the entrance of the jetties in the South Pass of the Mississippi River. May 6, 1878.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the sum of ten thousand dollars be, and the same is hereby, appropriated, out of any moneys in the Treasury not otherwise appropriated, for the erection and maintenance of pier lights, under the direction of the Light-House Board, at the entrance of the jetties in the South Pass of the Mississippi River. Appropriation: pier-lights at South Pass of Mississippi River.

Approved, May 6, 1878.

CHAP. 161.—An act making further appropriations for continuing the improvements of Galveston Harbor, State of Texas. June 7, 1878.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the sum of seventy-five thousand dollars be, and the same is hereby, appropriated, out of any moneys not otherwise appropriated, for the purpose of continuing the improvements of Galveston Harbor, in the State of Texas; which improvements are now being prosecuted under the direction of the Secretary of War, and the appropriation for which is substantially exhausted; and that the said sum be expended under his direction. Appropriation: Galveston Harbor.

Approved, June 7 1878.

CHAP. 180.—An act providing a permanent form of government for the District of Columbia. June 11, 1878.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, * * * * District of Columbia a corporation.

SEC. 2. That within twenty days after the approval of this act the President of the United States, by and with the advice and consent of the Senate, is hereby authorized to appoint two persons, who, with an officer of the Corps of Engineers of the United States Army, whose lineal rank shall be above that of captain, shall be Commissioners of the District of Columbia, and who, from and after July first, eighteen hundred and seventy-eight, shall exercise all the powers and authority now vested in the Commissioners of said District, except as are hereinafter limited or provided, and shall be subject to all restrictions and limitations and duties which are now imposed upon said Commissioners. The Commissioner who shall be an officer detailed, from time to time, from the Corps of Engineers, by the President, for this duty, shall not be required to perform any other, nor shall he receive any other compensation than his regular pay and allowances as an officer of the Army. Commissioners. Appointment. Powers. Engineer Commissioner.

* * * * * * *

SEC. 5. * * * * * *

* * * * * * *

The President of the United States may detail from the Engineer Corps of the Army not more than two officers, of rank subordinate to that of the engineer officer belonging to the Board of Commissioners of said District to act as assistants to said Engineer Commissioner, in the discharge of the special duties imposed upon him by the provisions of this act. Assistants to Engineer Commissioner.

* * * * * * *

Approved, June 11, 1878.

CHAP. 191.—An act making appropriations to supply deficiencies in the appropriations for the fiscal year ending June 30, 1878, and prior years, and for those heretofore treated as permanent, for reappropriations, and for other purposes. June 14, 1878.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the following sums be, and they are hereby, appropriated, to supply deficiencies in the appropria- Deficiency appropriations.

tions for the service of the government for the fiscal year ending Ju thirtieth, eighteen hundred and seventy-eight, and for former years, a for other purposes, namely:

* * * * * * *

Balances carried to surplus fund made available. 1874, ch. 328, 18 Stat., 110.

SEC. 2. That the following balances of appropriations, carried to t surplus fund under the provisions of the fifth section of the act approv June twentieth, eighteen hundred and seventy-four, being required complete the service of the fiscal year eighteen hundred and sevent five, and prior years, are hereby continued and rendered available f such purpose, namely:

* * * * * * *

WAR DEPARTMENT.

Survey of western, etc., rivers. 1870, ch. 292, 16 Stat., 300.

For examination and surveys on western and north-western rive there is reappropriated from the balance of fifty thousand dollars a propriated by act of July fifteenth, eighteen hundred and seventy, t sum of three hundred and thirty-four dollars and forty cents.

Sea-coast mortar-batteries. 1872, ch. 417, 17 Stat., 377.

For balance of one hundred thousand dollars appropriated by act July tenth, eighteen hundred and seventy-two, for construction of s coast mortar-batteries, three hundred and one dollars and fifty cents

Alluvial basin of Mississippi. 1874, ch. 411, 18 Stat., 199.

For balance of twenty-five thousand dollars appropriated by act June twenty-second, eighteen hundred and seventy-four, for commiss to investigate and report plan for reclamation of alluvial basin of M sissippi River, five thousand dollars.

* * * * * * *

Approved, June 14, 1878.

June 15, 1878.

CHAP. 216.—An act to authorize the Barataria Ship Canal Company to construct operate a ship canal from New Orleans to the Gulf of Mexico, through the lands waters of the United States, and to grant to said company the right of way for purpose.

Barataria Ship-Canal Company. Right of way, etc.

Be it enacted by the Senate and House of Representatives of the Un States of America in Congress assembled, That the Barataria Ship Ca Company, a body corporate of the State of Louisiana, created by an of the legislature of said State, approved April twenty-fourth, eight hundred and seventy-seven, be, and the same is hereby, granted the ri of way through the lands and waters of the United States, to en said company to construct and operate a ship-canal from a point a near the city of New Orleans to the Gulf of Mexico, through the B taria Bay, in the State of Louisiana, with power and authority to struct and maintain all necessary harbors, locks, dams, dikes, levees,

Proviso.

piers: *Provided*, The same shall in no manner interfere with or af the usual and ordinary navigation of said waters where they are confined either by piers or canal-banks constructed by said compa

Proviso.

and necessary for the use and operation of said canal: *And prov further*, That Bayou Villars shall not be closed by said canal compa

Rates of toll.

SEC. 2. That in the transportation of military or naval stores, tro or munitions of war of the United States, such rates of toll only shal charged as may be prescribed by the Secretary of War; and that tolls or tonnage charges of said company shall not exceed one dolla ton on the tonnage measurement of any vessel for the round trip thro said canal, or half said sum for less than the round trip; and not exc ing twenty-five cents for each passenger through said canal either w

Proviso.

Provided, That vessels of five tons burden and less shall be exempt f tolls for the use of said canal when they do not pass through the lo

Proviso.

And provided further, That no tolls shall be charged on any boats or sels navigating any of the waters on the line of said canal, which c have been navigated by such vessels had such canal not been built

Approved, June 15, 1878.

June 18, 1878.

CHAP. 263.—An act making appropriations for the support of the Army for the year ending June 30, 1879, and for other purposes.

Appropriations. Army.

Be it enacted by the Senate and House of Representatives of the U States of America in Congress assembled, That the following sums be, the same are hereby, appropriated, out of any money in the Trea

herwise appropriated, for the support of the Army, for the year
June thirtieth, eighteen hundred and seventy-nine, as follows:

* * * * * * *

NEER DEPARTMENT.—For engineer depot at Willets Point, New Engineer depot.
amely: For purchase of engineering materials to continue the
course of instruction of the engineer battalion in field engineer-
e thousand dollars.
ncidental expenses of the depot, remodeling ponton-trains, re-
instruments, fuel, forage, stationery, chemicals, extra-duty pay,
inary repairs, four thousand dollars.

* * * * * *

3. Allowance of or commutation for fuel to commissioned officers Allowance of
y prohibited; but fuel may be furnished to the officers of the fuel and forage.
y the Quartermaster's Department, for the actual use of such
only, at the rate of three dollars per cord for standard oak wood,
equivalent rate for other kinds of fuel, according to the regu-
now in existence; and forage in kind may be furnished to the
of the Army, by the Quartermaster's Department, only for horses
and actually kept by such officers in the performance of their
nilitary duties when on duty with troops in the field or at such
posts west of the Mississippi River, as may be from time to time
ted by the Secretary of War, and not otherwise as follows:
e General five horses;
e Lieutenant General four horses;
najor-general three horses;
rigadier-general, three horses;
olonel, two horses;
ieutenant-colonel, two horses;
najor, two horses;
aptain (mounted), two horses;
ieutenant (mounted), two horses;
adjutant, two horses;
egimental quartermaster, two horses.

). That at all posts and stations where there are public quarters Quarters in
ng to the United States, officers may be furnished with quarters kind.
in such public quarters, and not elsewhere, by the Quartermas-
partment, assigning to the officers of each grade, respectively,
mber of rooms as is now allowed to such grade by the rules and
ons of the Army: *Provided*, That at places where there are no Proviso.
uarters, commutation therefor may be paid by the Pay Depart- Commutation.
the officer entitled to the same at a rate not exceeding ten dol-
room per month, and the commutation for quarters allowed to
eral shall be at the rate of one hundred and twenty-five dollars
th, and to the Lieutenant General at the rate of seventy dollars
th.

* * * * * *

13. That from and after the passage of this act, all promotions Promotions and
Army, in each and every grade, arm, corps and department appointments.
shall cease; and thereafter no promotions or appointments shall
e to fill any vacancy which may occur, or be created therein,
ter such report shall be made and acted upon by Congress: *Pro-* Proviso.
hat this limitation shall not apply to the line of the Army below
k of captain.

* * * * * *

ved, June 18, 1878.

H.—An act making appropriations for the construction, repair, preservation, June 18, 1878.
npletion of certain public works on rivers and harbors, and for other pur-

enacted by the Senate and House of Representatives of the United America in Congress assembled, That the following sums of money Appropriations.
are hereby, appropriated, to be paid out of any money in the Rivers and harbors.
not otherwise appropriated, to be expended, under the direc-
he Secretary of War, for the repair, preservation, construction,
pletion of the public works hereinafter named:
proving Chester River, at Kent Island Narrows, Maryland, Chester River
usand dollars.
proving harbor at Baltimore, Maryland, seventy-five thousand Baltimore.

Wicomico River. For improving Wicomico River, Maryland, five thousand dollars.

James River. For improving James River, Virginia, seventy thousand dollars.

Appomattox River. For improving Appomattox River, Virginia, thirty thousand dollars.

Great Kanawha River. For improving Great Kanawha River, West Virginia, two hundred and twenty-two thousand dollars.

New River. For improving New River, from Lead Mines in Wythe County, Virginia, to mouth of Greenbrier River, fifteen thousand dollars.

Cape Fear River. For improving Cape Fear River, North Carolina, one hundred and sixty thousand dollars.

Occoquan River. For improving mouth of Occoquan River, Virginia: Completing the improvement, ten thousand dollars.

Aquia Creek. For improving Aquia Creek, Virginia: Completing the improvement, five thousand dollars.

Rappahannock River. For improving the Rappahannock River, Virginia, thirteen thousand five hundred dollars.

Elizabeth River. For improving South Branch of Elizabeth River, Virginia, five thousand dollars.

New Castle. For continuing construction of ice harbor at New Castle, Delaware, ten thousand dollars.

Norfolk. For improving harbor at Norfolk, Virginia, and its approaches, fifty thousand dollars.

French Broad River. For improving French Broad River, North Carolina, fifteen thousand dollars.

Nansemond River. For improving Nansemond River, Virginia: Completing the improvement, two thousand dollars.

Charleston. For improving harbor at Charleston, South Carolina, two hundred thousand dollars.

Savannah. For improving harbor at Savannah, Georgia, seventy thousand dollars.

Cedar Keys. For improving harbor at Cedar Keys, Florida, twenty thousand dollars.

Apalachicola River. For improving Apalachicola River, Florida, eight thousand dollars.

Chattahoochee River. For improving Chattahoochee River, Alabama and Georgia, eighteen thousand dollars.

Alabama River. For improving Alabama River, twenty-five thousand dollars.

Saint John's River. For deepening the bar at the mouth of Saint John's River, Florida, ten thousand dollars.

Port Clinton. For Port Clinton, Ohio, ten thousand dollars.

Flint River. For improving Flint River, Georgia, ten thousand dollars.

Warrior and Tombigbee Rivers. For improving the Warrior and Tombigbee Rivers, Alabama and Mississippi, forty thousand dollars; of which sum twenty-eight thousand dollars shall be expended on the Warrior and Tombigbee and twelve thousand dollars on the Tombigbee above Columbus.

Galveston Bay. 1876 ch. 267, 19 Stat., 138. For improvement of ship channel in Galveston Bay, Texas, between Boliver Channel and Red Fish Bar, seventy-five thousand dollars; and the appropriation made for this work by the act of fourteenth of August, eighteen hundred and seventy-six, is hereby made available for the same part of said channel.

Mississippi and Arkansas Rivers. For improving Mississippi and Arkansas Rivers: Continuing operations, removing snags, and other obstructions, one hundred and eighty thousand dollars; of which sum ten thousand dollars shall be used for removing the bar in the Arkansas River at Fort Smith.

Missouri River. For the survey of the Missouri River from its mouth to Sioux City, and estimates for the improvement and maintenance of its navigation, fifty thousand dollars.

Missouri River. For the improvement of the Missouri River: Removal of snags, wrecks, and so forth, seventy thousand dollars.

Galveston Harbor. For improving entrance to Galveston Harbor, Texas, fifty thousand dollars.

Sabine Pass. For improving Sabine Pass, Texas, deepening channel at the entrance and at Blue Buck Bar, thirty thousand dollars.

Passo Cavallo Inlet. For improving Passo Cavallo Inlet into Matagorda Bay, Texas, twenty-five thousand dollars.

Ouachita River. For improving Ouachita River, Arkansas and Louisiana, ten thousand dollars.

Yazoo River. For improving Yazoo River, Mississippi, twenty-five thousand dollars.

Red River. For removing raft in Red River and closing Tones Bayou, Louisiana, twenty-four thousand dollars.

Cypress Bayou. For improving Cypress Bayou, Texas and Louisiana, fifteen thousand dollars.

nnual expense of gauging the waters of the Lower Mississppi nd its tributaries: Continuing observations of the rise and fall iver and its chief tributaries, as required by joint resolution of y twenty-first, eighteen hundred and seventy-one, five thousand	Lower Mississippi River.
nproving White and Saint Francis Rivers, Arkansas, forty thou- llars.	White and St. Francis Rivers.
nproving the Missouri River, opposite or near Saint Joseph, Mis- fty thousand dollars.	Missouri River.
nproving mouth of Red River, Louisiana, one hundred and fifty d dollars.	Red River.
emoving obstructions in Pocomoke River, Maryland, ten thou- llars.	Pocomoke River.
he improvement of the Missouri River at Council Bluffs, Iowa, aha, Nebraska, fifty thousand dollars.	Missouri River.
nproving the Missouri River, at Nebraska City, Nebraska, thousand dollars.	Missouri River.
nprovement of L'Anguille River, Arkansas, ten thousand dollars.	L'Anguille River.
emoving bar in Mississippi River, opposite Dubuque, Iowa, ten d dollars.	Mississippi River.
nproving Rush Chute and the harbor of Burlington, Iowa, ten d dollars.	Burlington.
nproving harbor at Fort Madison, Iowa, eight thousand dollars.	Fort Madison.
nproving Rock Island Rapids, Mississippi River, thirty thousand	Rock Island Rapids.
nproving Illinois River, seventy-five thousand dollars.	Illinois River.
he improvement of the Mississippi River, between the mouths of o and Illinois Rivers, two hundred and forty thousand dollars; h sum twenty thousand dollars shall be expended between the of the Illinois and Missouri Rivers; seventy-five thousand dol- constructing dam at Cahokia Chute, opposite Saint Louis; forty d dollars between the foot of Dickey's Island and the mouth of io River; and ten thousand dollars between Islands Numbers n and Fifteen, near the town of Kaskaskia, Illinois.	Mississippi River.
emoving snags and other obstructions from Red River, Louisiana, five thousand dollars.	Red River.
he improvement of the Missouri River above the mouth of the tone, thirty thousand dollars.	Missouri River.
he improvement of the Mississippi River: Widening and deep- he channel from Saint Paul to Des Moines Rapids, two hundred y thousand dollars.	Mississippi River.
idening and deepening the channel of the Mississippi River es Moines Rapids to the mouth of the Ohio, one hundred thou- llars.	Mississippi River.
he improvement of Mobile Harbor, ten thousand dollars, to be to making tests, surveys, and borings to determine whether the annel now leading from the lower anchorage in Mobile Bay can ened so as to admit vessels drawing twenty-two feet, or any less t above thirteen feet, to the wharves of the city of Mobile.	Mobile Harbor.
he improvement of Cumberland River above Nashville, Tennes- ty thousand dollars; of which sum twenty thousand dollars expended between Nashville and the Kentucky line; thence to t of Smith's Shoals, eight thousand dollars; and for Smith's thirty thousand dollars; thence to the falls of the Cumberland, usand dollars.	Cumberland River.
nproving Minnesota River, ten thousand dollars.	Minnesota River.
mproving Red River of the North, Minnesota, thirty thousand	Red River.
nproving Tennessee River: Continuing operations above Chat- , fifteen thousand dollars; continuing operations below Chatta- ncluding Muscle Shoals, three hundred thousand dollars; fifteen d dollars of which sum, or so much thereof as may be necessary, pended in the improvement of Duck River Shoals, on Tennes- er.	Tennessee River.
nproving Cumberland River, below Nashville, Tennessee, forty- nsand dollars.	Cumberland River.
nproving Coosa River, between Rome, Georgia, and the Selma, nd Dalton Railroad bridge, Alabama, seventy-five thousand	Coosa River.

Hiawassee River.	For improving Hiawassee River, Tennessee, ten thousand dollars.
Ocmulgee River.	For improving Ocmulgee River, Georgia, fifteen thousand dollars.
Oostenaula and Coosawattee Rivers.	For improving Oostenaula and Coosawattee Rivers, Georgia, four thousand dollars.
Little Kanawha River.	For improving Little Kanawha River, West Virginia, eighteen thousand dollars.
Wabash River.	For improving Wabash River, Indiana, fifty thousand dollars.
Superior Bay.	For dredging Superior Bay, Wisconsin: Improving natural entrance to Superior Bay, three thousand dollars; continuing improvement of the harbor of Duluth, thirty thousand dollars.
Ontonagon.	For improving harbor at Ontonagon, Michigan, fifteen thousand dollars.
Eagle Harbor.	For improving Eagle Harbor, Michigan, eight thousand dollars.
Marquette.	For improving harbor at Marquette, Michigan, two thousand dollars.
Menomonee.	For improving harbor at Menomonee, Wisconsin, ten thousand dollars.
Green Bay.	For improving harbor at Green Bay, Wisconsin, five thousand dollars.
Sturgeon Bay.	For improving harbor of refuge, entrance at Sturgeon Bay Canal, thirty thousand dollars.
Ahnapee.	For improving harbor at Ahnapee, Wisconsin, eight thousand dollars.
Two Rivers.	For improving harbor at Two Rivers, Wisconsin, ten thousand dollars.
Manitowoc.	For improving harbor at Manitowoc, Wisconsin, fifteen thousand dollars.
Sheboygan.	For improving harbor at Sheboygan, Wisconsin, four thousand dollars.
Port Washington.	For improving harbor at Port Washington, Wisconsin, five thousand dollars.
Mississippi River.	For improving the Mississippi River from the bridge of the Chicago, Milwaukee and Saint Paul Railroad Company above La Crosse, Wisconsin, to the mouth of Root River, below said city, twelve thousand five hundred dollars.
Ohio River.	For improving and deepening the channel of the Ohio River, including the removal of snags, wrecks, and so forth, from Pittsburgh to its mouth, three hundred thousand dollars; of which sum fifty thousand dollars shall be expended at Grand Chain for removal of obstructions and deepening the channel at that point.
Cincinnati.	For the construction of a harbor or harbors of refuge, at or near Cincinnati, to protect the commerce of the Ohio River from floes of ice, fifty thousand dollars, to be expended under the direction and control of the Engineer Corps of the Army.
New Orleans.	For improvement of the harbor at New Orleans, Louisiana, including cost of surveys and estimates fifty thousand dollars.
Monongahela River.	For the improvement of Monongahela River, West Virginia and Pennsylvania, to be expended in completing lock and dam at Hoard's Rocks twenty-five thousand dollars.
Michigan City.	For the improvement of harbor at Michigan City, Indiana, seventy five thousand dollars; of which sum twenty-five thousand dollars shall be expended for the improvement of the inner harbor.
Bath.	For the improvement of Gut opposite Bath, Maine, seventeen thousand dollars.
Waddington Harbor.	For the improvement of Waddington Harbor, New York, five thousand dollars.
Oakland Harbor.	For the improvement of Oakland Harbor, California, eighty thousand dollars; but this sum shall not be available until the right of the United States to the bed of the estuary and training walls of this work is secured, free of expense to the government, in a manner satisfactory to the Secretary of War.
Milwaukee.	For improving harbor at Milwaukee, Wisconsin, fifteen thousand dollars.
Racine.	For improving harbor at Racine, Wisconsin, ten thousand dollars.
Kenosha.	For improving harbor at Kenosha, Wisconsin, eight thousand dollars.
BrazosSantiago.	For removing wrecks and other obstructions to navigation at Brazos Santiago, Texas, six thousand dollars.
Fox and Wisconsin Rivers.	For improving Fox and Wisconsin Rivers, two hundred and fifty thousand dollars.

nproving harbor at Chicago, Illinois: Extending breakwater lging channel, seventy-five thousand dollars.	Chicago.
nproving harbor at Calumet, Illinois, fifteen thousand dollars.	Calumet.
nproving harbor at Charlevoix, Michigan, twelve thousand	Charlevoix.
nproving harbor at Frankfort, Michigan, eight thousand eight dollars.	Frankfort.
nproving harbor at Manistee, Michigan, fifteen thousand dol-	Manistee.
proving harbor at Ludington, Michigan, fifteen thousand dol-	Ludington.
proving harbor at Pentwater, Michigan, ten thousand dollars.	Pentwater.
nproving harbor at White River Michigan, twelve thousand	White River Harbor.
nproving harbor at Grand Haven, Michigan, fifteen thousand	Grand Haven.
proving harbor at Black Lake, Michigan, ten thousand dol-	Black Lake.
proving harbor at Saugatuck, Michigan, two thousand five dollars.	Saugatuck.
moving obstructions in Bayou La Fourches, Louisiana, ten dollars.	Bayou La Fourches.
proving harbor at South Haven, Michigan, twelve thousand	South Haven.
proving Harbor at Saint Joseph, Michigan, twelve thousand	Saint Joseph.
proving Saint Mary's River and Saint Mary's Falls Canal, , one hundred and seventy-five thousand dollars.	Saint Mary's River, etc.
proving Harbor of Refuge, Lake Huron, Michigan, one hun- sand dollars.	Harbor of Refuge, Lake Huron.
proving Saint Clair River at mouth of Black River, Michigan, sand five hundred dollars.	Saint Clair River.
proving Detroit River, Michigan, one hundred thousand dol-	Detroit River.
proving Saint Clair Flats, Michigan, five thousand dollars.	Saint Clair Flats.
proving Saginaw River, Michigan, twenty-five thousand dol-	Saginaw River.
proving harbor at Cheboygan, Michigan, eight thousand dol-	Cheboygan.
proving harbor at Monroe, Michigan, two thousand five hun- ars.	Monroe.
proving harbor at Toledo, Ohio, fifty thousand dollars.	Toledo.
improvement of Guyandotte River, West Virginia, two thou- ars.	Guyandotte River.
improvement of the Raritan River, New Jersey, two hundred dollars.	Raritan River.
improvement of Blackwater River, Virginia, five thousand	Blackwater River.
improvement of the Hampton River, Virginia, ten thousand	Hampton River.
improvement of Chickahominy River, Virginia, five thousand	Chickahominy River.
improvement of the Narrows above Orange, on the Sabine xas, and deepening the channel at the mouth of said river, and dollars.	Sabine River.
pening the channel at the mouth of the Trinity River, Texas, ring obstructions to Liberty, ten thousand dollars.	Trinity River.
pening the channel at the mouth of the Neches River, Texas, ring obstructions to Beaumont, eight thousand dollars.	Neches River.
proving Pascagoula River, Mississippi, and deepening the t its mouth, ten thousand dollars.	Pascagoula River.
improvement of the harbor and the Mississippi River at Mem- nessee, forty-six thousand dollars.	Memphis.
improvement of Elk River, West Virginia, five thousand dol-	Elk River.
proving harbor at Sandusky City, Ohio, twenty thousand dol-	Sandusky Cit
proving harbor at Huron, Ohio, one thousand dollars.	Huron.
proving harbor at Vermillion, Ohio, four thousand dollars.	Vermillion.

Cleveland. For breakwater at Cleveland, Ohio, and repairs of harbor, one l dred thousand dollars.

Fairport. For improving harbor at Fairport, mouth of Grand River, Ohio, thousand dollars.

Ashtabula. For improving harbor at Ashtabula, Ohio, twelve thousand dolla

Erie. For improving harbor at Erie, Pennsylvania, twenty-five thou dollars.

Buffalo. For improving harbor at Buffalo, New York, eighty thousand dol

Oak Orchard. For improving harbor at Oak Orchard, New York, two thousand lars.

Charlotte. For improving harbor at Charlotte, New York, one thousand doll

Pultneyville. For improving harbor at Pultneyville, New York, five thousand lars.

Great Sodus Bay. For improving harbor at Great Sodus Bay, New York, five thou dollars.

Little Sodus Bay For improving harbor at Little Sodus Bay, New York, ten thou dollars.

Oswego. For improving harbor at Oswego, New York, ninety thousand do

Wilmington. For breakwater at Wilmington, California, twenty thousand do

Sacramento and Feather Rivers. For improving Sacramento and Feather Rivers, California, fi thousand dollars.

Lower Willamette and Columbia Rivers. For improving Lower Willamette and Columbia Rivers, from land, Oregon, to the sea, thirty thousand dollars.

Upper Willamette River. For improving Upper Willamette River, Oregon, twenty thousan lars.

Upper Columbia River. For improving Upper Columbia River, including Snake River, tw thousand dollars.

Cascades, Columbia River. For constructing a canal around the Cascades of Columbia Rive hundred and fifty thousand dollars.

Big Sandy River. For the improvement of Big Sandy River, from Catlettsburg, tucky, to the head of navigation, twelve thousand dollars.

Columbia River. For the improvement of the mouth of the Columbia River, Or five thousand dollars, the same or so much thereof as may be n sary to be expended under the direction of the Secretary of W making a thorough survey of the bar at the mouth of said rive in the preparation of a plan and estimates for its permanent imp ment; any balance to be used in the temporary improvement of bar.

Chester. For repairs of ice-harbor at Chester, Pennsylvania, three thou four hundred dollars.

Oconee River. For the improvement of the Oconee River, Georgia, ten thou dollars; of which sum eight thousand dollars shall be expended bet Dublin and the Central Railroad bridge, and two thousand dolla tween Dublin and Ocmulgee River.

Galena River. For the improvement of Galena River, Illinois, making a chan one hundred feet width, and the improvement, of the harbor of Ga thirty thousand dollars.

Vicksburg. For the improvement of the Mississippi River at and near Vicks Mississippi, and protection of harbor at Vicksburg, Mississippi ei four thousand dollars.

Salem River. For improving the channel of Salem River, New Jersey, and re ing obstructions in the Delaware River at the mouth of Salem R three thousand dollars.

Missouri River. For improving the Missouri River at Omaha City, Nebraska, t thousand dollars.

Saint Croix River. For the improvement of the Saint Croix River, Wisconsin, ten sand dollars.

Chippewa River. For completing and protecting wing dams and jetties now in c of construction upon the Chippewa River in Wisconsin in and ne mouth and below the lower point of Beef Island, ten thousand do

Proviso. *Provided*, That nothing herein shall be construed, nor shall any ex iture of this appropriation be made, so as to affect existing leg equitable rights in or upon the said Chippewa River or its bran whether such rights arise under the laws of the United States o State of Wisconsin.

Missouri River. For the improvement of the Missouri River at Atchison, Ka twenty thousand dollars.

Missouri River. For the improvement of the Missouri River at Eastport, Iowa, Nebraska City, Nebraska, twenty thousand dollars.

improvement of the Osage River in Missouri and Kansas, ousand dollars.	Osage River.
improvement of the Missouri River at or near Fort Leavan- nsas, twenty-five thousand dollars.	Missouri River
roving the Missouri River at Sioux City, Iowa, twelve thou- undred dollars.	Missouri River.
mprovement of the Neuse River, North Carolina, forty thou- rs.	Neuse River.
mprovement of the harbor, including survey and estimate for wrecks at Pensacola, Florida, twenty thousand dollars.	Pensacola.
mprovement of Currituck Sound and North River Bar, North wenty thousand dollars.	Currituck Sound.
improvement of Scuppernong River, North Carolina, two lollars.	Scuppernong River.
mprovement of Edenton Harbor, North Carolina, four thou- s.	Edenton Harbor.
pleting the improvement of Black River Harbor, Ohio, one lollars.	Black River Harbor.
improvement of the harbor at New Haven, Connecticut, e thousand dollars.	New Haven.
improvement of the harbor at Darien, Georgia, eight thou- rs.	Darien.
inuing the improvement of Penobscot River, Maine, twelve lollars; of which sum two thousand five hundred dollars, or ereof as may be necessary, shall be expended at or near the said river at Bucksport.	Penobscot River.
improvement of the harbor at Bridgeport, Connecticut, ten dollars; of which sum not less than one-half shall be ex- tween the lower bridge and the horse-railroad bridge.	Bridgeport.
improvement of Harlem River, New York, three hundred lollars; but this sum is not to be available until the right of is work is secured to the United States free of cost.	Harlem River.
roving harbor at Belfast, Maine, twelve thousand dollars.	Belfast.
roving Richmond Island Harbor, Maine, six thousand dollars.	Richmond Island Harbor.
roving Cocheco River, New Hampshire, six thousand dollars.	Cocheco River.
roving Merrimac River, Massachusetts, below Mitchell's Falls, nd dollars.	Merrimac River.
roving harbor at Boston, Massachusetts, fifty-five thousand	Boston.
roving harbor at Plymouth, Massachusetts, five thousand	Plymouth.
roving harbor at Provincetown, Massachusetts, one thousand	Provincetown.
roving harbor at Hyannis, Massachusetts, three thousand	Hyannis.
roving Taunton River, Massachusetts, two thousand dollars.	Taunton River.
roving Providence River, Rhode Island; Removing Bulkhead thousand dollars.	Providence River.
roving Little Narragansett Bay, Rhode Island and Connecti- ousand dollars.	Little Narragansett Bay.
roving Providence River and Narragansett Bay, fifty thou- rs.	Providence River.
improvement of Echo Harbor, New Rochelle, New York, ten dollars.	Echo Harbor.
improvement of Staten Island Sound, between New Jersey n Island, fifteen thousand dollars.	Staten Island Sound.
roving the harbor of Breton Bay, Leonardtown, Maryland, and dollars.	Breton Bay.
roving the inner harbor at Cambridge, Maryland, five thou- rs.	Cambridge.
roving the harbors and channels at Washington and George- trict of Columbia, fifty thousand dollars; of which sum twenty dollars is to be expended in Washington harbor and channel Long Bridge, and thirty thousand dollars to be expended in n harbor and channel.	Washington and Georgetown.
proving Connecticut River, below Hartford, Connecticut, sand dollars; of which sum five thousand dollars shall be edging the river between Hartford and Middletown; and two dollars for improving the mouth of Salmon River in the town ddam.	Connecticut River.

Stonington. For improving harbor at Stonington, Connecticut, forty thous dollars.

Thames River. For improving Thames River, Connecticut, ten thousand dollars.

Milford. For improving harbor at Milford Connecticut, ten thousand doll

Housatonic River. For improving Housatonic River, Connecticut, five thousand doll

Norwalk. For improving harbor at Norwalk, Connecticut, six thousand doll

Port Jefferson. For improving harbor at Port Jefferson, Long Island Sound, N York, eight thousand dollars.

Hudson River. For improving Hudson River, New York, seventy thousand dollar

Hell Gate. For removing obstructions in East River and Hell Gate, New Y three hundred and fifty thousand dollars.

Passaic River. For improving Passaic River, New Jersey, ten thousand dollars.

East Chester Creek. For improving East Chester Creek, New York, ten thousand doll

Rondout. For improving harbor at Rondout, New York, thirty thousand doll

Burlington. For improving harbor at Burlington, Vermont, twenty thousand lars.

Swanton. For improving harbor at Swanton, Vermont, twenty thousand doll

Otter Creek. For improving Otter Creek, Vermont, eight thousand dollars.

Lewes. For constructing piers in Delaware Bay, near Lewes, Delaware, tw thousand dollars.

Wilmington. For improving harbor at Wilmington, Delaware, seven thousand lars.

Schuylkill River. For improving Schuylkill River, Pennsylvania, thirty thousand lars.

Delaware River. For improving Delaware River, below Bridesburg, one hundred t sand dollars.

Delaware River. For improving Delaware river, between Trenton and White Hill, Jersey, ten thousand dollars.

Shrewsbury River. For improving north and south branches of Shrewsbury River, Jersey, eighteen thousand dollars.

Cohansey Creek For improving Cohansey Creek, New Jersey, five thousand dolla

Des Moines Rapids. For improving Des Moines Rapids, and operating the canal, ni five thousand dollars.

Upper Mississippi River. For improving Upper Mississippi River, from the mouth of the nois: Removal of snags and obstructions, forty-one thousand five dred dollars.

South Pass. For continuing surveys and examinations at the South Pass o Mississippi River, fifteen thousand dollars.

Use and expenditure of appropriations. It shall be the duty of the Secretary of War to apply the m herein appropriated for improvements, other than surveys and mates, in carrying on the various works by contract or by hired l at his discretion, and as in his judgment may be most advantageo the government; and, where said works are done by contract, such tracts shall be made after sufficient public advertisement for prop in such manner and form as the Secretary of War shall prescribe; such contracts shall be made with the lowest responsible bidders t for, accompanied by such securities as the Secretary of War sha quire.

Surveys and examinations. SEC. 2. That the Secretary of War is hereby directed at his discr to cause examinations or surveys, or both, and estimates of cost o provements proper to be made at the following points, namely:

Portsmouth. Portsmouth Harbor, New Hampshire;

Red River Falls. For improving the navigation at the Falls on Red River near Al dria, Louisiana;

Mispillion Creek. The Mispillion Creek, Delaware;

Cape Foulweather. Cape Foulweather, Oregon, to ascertain its adaptability as a h of refuge;

Coos Bay. The entrance of Coos Bay;

Conecuh, etc., Rivers. The Conecuh, Patsaligo, and Escambia Rivers, Alabama;

Yadkin River. The Yadkin, North Carolina, between the bridge on the North lina Railroad and Wilkesborough;

Flushing Bay. Flushing Bay, New York;

Thames River. The Thames River Connecticut;

Big Sunflower, etc., rivers. The Big Sunflower, Chickasahoy, Tallahatchie, Cold Water, P and Pascagoula, Mississippi; and the expenses of survey of the P goula shall be defrayed out of the sum herein appropriated for th provement thereof;

ı Landing River, Virginia;	North Landing River.
cock Harbor, Virginia;	Anancock Harbor.
Salem River, New Jersey, between Sharpstown and Delaware	Salem River.
uwannee River, Florida;	Suwannee River.
aloosahatchie River, Florida;	Caloosahatchie River.
sippi River at and above the city of Alexandria, Missouri;	Mississippi River.
outh of Hillsborough River and Tampa Bay, Florida;	Hillsborough River.
s Fork and Obey's Rivers, Tennessee;	Caney's Fork and Obey's River.
Bartholemew, Arkansas;	Bayou Bartholomew.
Red River, from the raft up to the Missouri, Kansas and Texas bridge; and also the Brazos River in Texas from eight miles mouth, down through its mouth to the outer edge of the bar ılf of Mexico.	Upper Red River. Brazos River.
s Pass and Bay, up to Rockport and Corpus Christi, Texas; ous Christi Pass and Channel;	Aransas Pass.
River, Arkansas;	Little River.
River, Arkansas;	Saline River.
r at the mouth of Brazos River, Texas, including a report upon city of the harbor at the mouth of the Brazos, and its adapta- a harbor of refuge and naval station;	Brazos River.
issouri River at Cedar City, in Callaway County, Missouri;	Missouri River.
ri River at the city of St. Charles, Missouri;	
Stone River;	Yellow Stone River.
ottoway River, Virginia;	Nottoway River.
ast of Long Island, New York, between Coney Island Point kaway Inlet, in New York Bay;	Long Island coast.
shead Bay, New York;	Sheepshead Bay.
sie Bay, New York;	Canarsie Bay.
hattahoochee River, Georgia, above Columbus;	Chattahoochee River.
lint River, Georgia, from Albany to Montezuma;	Flint River.
towah River, Georgia;	Etowah River.
avannah River, above Augusta, Georgia;	Savannah River.
onche La Fave in Arkansas;	Fonche La Fave.
arbor of San Luis Obispo, California, with a view to the prac- y of building breakwater;	San Luis Obispo.
arbor of San Buenaventura, California, with a view to the bility of building breakwater;	San Buenaventura.
arbor of Santa Barbara, California, with a view to the practi- of building breakwater;	Santa Barbara.
ississippi River, to ascertain the practicability, cost, and utility e from Bloody Island, opposite the city of Saint Louis, Missouri, the dike or dam opposite Brooklyn, on the Illinois shore;	St. Louis dike.
rey and estimate of the damages, if any, done, or to be done, an owners of lands, and improvements thereon, at or in front own of Venice, Illinois, near Saint Louis, Missouri, by reason mment improvements made, or to be made, at or near said town ce;	Damages at Venice.
River, Virginia, from Clarksville, via Danville, Virginia, to Dan- orth Carolina;	Dan River.
ton River, from Roanoke Depot, in Charlotte County, Virginia, neal, in the county of Campbell, Virginia;	Staunton River.
River, from the Lead Mines in Wythe County to the mouth of n Grayson County, Virginia;	New River.
arbor at Quincy, Illinois;	Quincy.
Bayou, Bayous Pierre and Wincey and Lakes Bayou Pierre nasanier, Louisiana;	Tones Bayou, etc.
te Harbor, Massachusetts, with a view to its adaptability as a f refuge;	Scituate.
pahoe River, Louisiana;	Tongapahoe River.
River, from Lake Boygan to Red River, Wisconsin;	Wolf River.

Arkansas River.	The Arkansas River, from Fort Smith, Arkansas, to the mouth Little Arkansas;
Woodbridge Creek.	Woodbridge Creek, Middlesex County, New Jersey;
Elizabeth River.	Elizabeth River, New Jersey;
Rahway River.	Rahway River, New Jersey;
Charles River.	Charles River, Massachusetts, to the head of tide-water;
Manasquan River.	Manasquan River New Jersey;
White River.	White River, Indiana, including the East Fork to the new bridge course of construction near Bedford, and the West Fork to the town Gosport;
Portage Lake.	Portage Lake, Manistee County, Michigan, with a view to its adapt bility as a harbor of refuge;
Westport.	Westport Harbor, Massachusetts;
Wood's Holl.	Wood's Holl, Massachusetts;
Peedee River.	Peedee River, from Cheraw, South Carolina, to the mouth of Uwha River, North Carolina;
Annapolis.	The bars at the entrance of Annapolis Harbor, Maryland, with a vi to accommodation of deep-draught vessels at low tide;
Patapsco River West Branch.	West Branch of Patapsco River, Maryland, from Lightstreet bri to head of tide-water, and an estimate of the cost of making the sa navigable for canal-boats;
Kentucky River.	The Kentucky River and navigable tributaries, Kentucky;
Licking River.	The Licking River, Kentucky;
Cumberland Falls.	The falls of the Cumberland, Kentucky;
Clearwater River.	Clearwater River, Idaho;
Missouri and Kansas Rivers.	The Missouri and Kansas Rivers, at and near their junction;
Trent River.	The Trent River, North Carolina;
Neuse River.	Neuse River, from Smithfield to Goldsborough, North Carolina;
Chowan River.	Chowan River, North Carolina;
Tar River.	The Tar River, North Carolina, from Washington to Tarborough;
Humboldt River.	Humboldt River, California, with a view to its adaptability as a h bor of refuge;
Crescent City Harbor.	Crescent City Harbor, California, with a view to its adaptability a harbor of refuge;
Reservoirs on Mississippi, St. Croix, Chippewa, and Wisconsin Rivers.	The examination of the sources of the Mississippi River and of Saint Croix River in Wisconsin and Minnesota, and of the Chipp and Wisconsin Rivers in the State of Wisconsin, to determine the p ticability and cost of creating and maintaining reservoirs upon headwaters of said rivers and their tributaries for the purpose of re lating the volume of water and improving the navigation of said riv and that of the Mississippi River, and an estimate of the damag result therefrom to property of any kind;
Muskingum River.	The Muskingum River, Ohio, below the second dam, to ascertain adaptability for an ice-harbor, for the protection of steamers and o craft on the Ohio River;
Colorado of the West.	Colorado of the West from Fort Yuma to El Dorado Canon;
Kiskiminetas and Conemaugh Rivers.	The Kiskiminetas and Conemaugh Rivers, Pennsylvania, from mouth of the Kiskiminetas to the mouth of Stony Creek on the C maugh;
Allegheny River.	The Allegheny River, up to the mouth of French Creek;
Kankakee River.	The Kankakee River, Illinois and Indiana;
Lincolnville Harbor.	Lincolnville Harbor, Maine;
Lubec Channel.	Lubec Channel, Maine;
Apalachicola Bay.	Apalachicola Bay, Florida;
East River.	East River, New York, at its junction with Newtown Creek;
Maryland and Delaware peninsula canal.	The peninsula of Maryland and Delaware, with a view to a const tion of a ship-canal to connect the waters of the Delaware and Chesap Bays;
Florida peninsula canal.	The peninsulas of Florida with a view to the construction of a canal from the Saint Mary's River to the Gulf of Mexico;
Duck Creek.	Duck Creek, Delaware;
St. John's River.	The mouth of Saint John's Piver, Florida;
Kansas River.	The Kansas River from its mouth to Junction City, Kansas;

Delaware River below Leagne Island; Delaware River.
nrvey of the Saint John's River, Florida, between Lake George St. John's River.
ke Monroe, and estimates of cost of deepening the Volusia Bar
aightening the river by cut-offs;
Orford, Oregon, to ascertain its adaptability for a harbor of Port Orford.

e River, Oregon, between Scottsburg and its mouth; Rogue River.
ille River, Oregon; Coquille River.
River and Bay, Oregon; Alsea River and Bay.

the sum of twenty thousand dollars is hereby appropriated, out Water lines from Norfolk to Cape Fear River.
moneys in the Treasury not otherwise provided for, for the pur-
having a complete survey and examination of all the water lines
tes leading or that may lead from the Harbor of Norfolk to the
Ocean south of Hatteras, including any communication that
practicable with the Cape Fear River; and the said examina- What lines to be surveyed.
l survey shall embrace the line known as the Dismal Swamp line
line known as the Albermarle and Chesapeake Canal line, and
routes and lines that may be practicable in the waters of Eastern
arolina connecting Norfolk Harbor by inland navigation with
n south of Cape Hatteras.

. That for the examinations and surveys herein provided for, Examinations, etc.; appropriation.
incidental repairs of harbors for which there is no special ap-
ion, the sum of one hundred and fifty thousand dollars is hereby
iated, to be paid out of any moneys in the Treasury not other-
propriated.

oved, June 18, 1878.

10.—An act granting a site for a dry-dock in the city of Baltimore upon certain conditions. June 19, 1878.

enacted by the Senate and House of Representatives of the United America in Congress assembled, That the Secretary of War be, Fort McHenry tract, Baltimore.
s hereby, directed to convey to the Baltimore Dry Dock Com-
Baltimore City, a body corporate created under the laws of the Part of, to be conveyed as site for dry-dock.
Maryland, for the consideration hereinafter described, so much
and belonging to the United States, in said city, known as the
Henry tract, as lies between the northwestern boundary line of
tract, and a line parallel thereto and distant four hundred and
t therefrom, and between a line two hundred and fifty feet from
thern side of Fort avenue (a street or avenue of said city, ex-
, and parallel thereto, and the northwest branch of the Patapsco

. That in consideration of the said conveyance, and as the con- Conditions of conveyance.
pon which the same is made, the said dry-dock company shall
ired to construct, upon the land conveyed as aforesaid, within
ars from the date of the conveyance, an efficient "Simpson's
d dry-dock", four hundred and fifty feet in length, and to
to the United States the right to the use forever of the said dry-
t any time, for the prompt examination and repair of vessels
ng to the United States, free from charge for docking; and if at Diversion to other uses.
e said property hereby conveyed shall be diverted to any other
n that herein named, or if the said dry-dock shall be at any time
r use for a period of six months, or more, the property hereby
d with all its privileges and appurtenances shall revert to, and
the absolute property of the United States.

oved, June 19, 1878.

13.—An act to amend an act entitled "An act making appropriations for the preservation, and completion of certain public works on rivers and harbors, other purposes," approved March 3, A. D. 1875. June 19, 1878.

enacted by the Senate and House of Representatives of the United America in Congress assembled, That the fourth and succeeding James B. Eads. Payments to, how to be made. 1875, ch. 134, 18 Stat., 463. Amended.
of an act entitled "An act making appropriations for the repair,
tion, and completion of certain public works on rivers and har-
d for other purposes", approved March third, anno Domini
hundred and seventy-five authorizing James B. Eads and his

associates to create and permanently maintain a wide and deep channel between the South Pass of the Mississippi River and the Gulf of Mexico, be, and they are hereby, amended so as to provide that payments shall be made to said Eads, his assigns or legal representatives, as follows, namely:

Payment of five hundred thousand dollars.

SEC. 2. The Secretary of War is hereby authorized and directed to draw his warrant upon the Secretary of the Treasury of the United States in favor of James B. Eads, his assigns or legal representatives, for the sum of five hundred thousand dollars, so soon as the said Eads, his lawful assigns or legal representatives, shall file with the said Secretary of War a relinquishment of all claim to the payment of five hundred thousand dollars provided by the hereinbefore recited act to be paid when a channel twenty-four feet in depth and not less than two hundred and fifty feet in width shall have been obtained. And the Secretary of the Treasury is hereby authorized and directed to pay to said Eads, his lawful assigns or legal representatives, the sum for which said warrant is drawn.

Monthly payments, amounting to five hundred thousand dollars.

SEC. 3. The Secretary of War is further hereby authorized and directed upon his approval of the engineers statement in this section mentioned to draw his warrant upon the Secretary of the Treasury of the United States in favor of said James B. Eads, his lawful assigns or legal representatives, monthly, for such sums, not exceeding in the aggregate the gross sum of five hundred thousand dollars, as he or they may require in the prosecution of the works authorized by said hereinbefore recited act, to pay for materials furnished, labor done, and expenditures incurred, from and after the passage of this act, in the construction of said works: *Provided*, That said Eads or his legal representatives, shall file in the office of the Secretary of War, with each requisition made by him or them, a certified statement, which shall be made by the engineer officer provided for in said act, that the requisition is for the amount of work properly done, materials furnished, and expenditures incurred in the prosecution of the work: *And provided*, That said Eads, his lawful assigns or legal representatives shall file with the Secretary of War a relinquishment of all claim to the deferred payment of two hundred and fifty thousand dollars provided by the hereinbefore recited act to be paid when a channel twenty-four feet in depth and not less than two hundred and fifty feet in width shall have been maintained for twelve months consecutively: *And provided further*, That said Eads, his lawful assigns or legal representatives shall from time to time, as monthly installments of the remaining two hundred and fifty thousand dollars are paid, file with the Secretary of War a relinquishment of like amounts, to be deducted from the payment of five hundred thousand dollars provided by the hereinbefore recited act to be paid when a channel twenty-six feet in depth and not less than three hundred feet in width shall have been obtained. And the Secretary of the Treasury is hereby authorized and directed to pay to said Eads, his lawful assigns or legal representatives, the sums for which said warrants are drawn. All other payments to said James B. Eads his lawful assigns or legal representatives are to be made under and in pursuance of the provisions of the hereinbefore recited act; the whole of said act, except as the same is hereby expressly modified or amended, to have the same force and effect as if this act had not been passed.

Certificates of work, etc.

Relinquishment of deferred payment.

Further relinquishment.

Remaining payments according to former act.

Board of engineers to examine and report.

SEC. 4. The President of the United States is hereby authorized and directed to convene a board of five engineers of the Army, which said board shall visit the works in process of construction by said James B. Eads at the South Pass of the Mississippi River, and make an examination of the same, and make a full report of the progress made in the construction of the works, the probable cost of their completion, and the results produced, or that may properly be produced by them, their probable permanency, and of the advisability of any modification of the terms of the act under which said Eads is constructing said works, so far as regards dimensions of channel through the jetties, and of the terms of payment for the same; which said report shall be submitted to the Secretary of War, to be presented at the next session of Congress.

Approved, June 19, 1878.

CHAP. 329.—An act making appropriations for the legislative, executive, and judicial expenses of the government for the fiscal year ending June 30, 1879, and for other purposes. June 19, 1878.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the following sums be, and the same are hereby, appropriated, out of any money in the Treasury not otherwise appropriated, in full compensation for the service of the fiscal year ending June thirtieth, eighteen hundred and seventy-nine, for the objects hereinafter expressed, namely: Appropriations. Legislative, executive, and judicial expenses.

* * * * * * *

WAR DEPARTMENT.

* * * * * * *

IN THE OFFICE OF THE CHIEF OF ENGINEERS.—One chief clerk, at two thousand dollars; four clerks of class four; two clerks of class three; three clerks of class two; three clerks of class one; one clerk, at one thousand dollars; one assistant messenger; and two laborers; in all, twenty-three thousand two hundred and forty dollars. Engineer Bureau.

That the Secretary of War is hereby authorized to detail not exceeding thirty enlisted men for clerical service in his department in addition to the force above provided.

For contingent expenses, namely: For stationery, office furniture, miscellaneous and incidental expenses, including purchase of professional books and maps, two thousand five hundred dollars.

* * * * * * *

PUBLIC BUILDINGS AND GROUNDS.

For clerk in the office of Public Buildings and Grounds, one thousand four hundred dollars; and for messenger in the same office eight hundred and forty dollars. For rent of a portion of the building known as the Towson House, for the use of the clerical force employed under the Chief of Engineers of the Army upon the public buildings and grounds of the Government of the United States in the District of Columbia, for office for records and for transaction of business relating to the same, nine hundred dollars. Salaries, etc.

For the public gardener, one thousand six hundred dollars.

For a foreman and laborers employed in the public grounds, twenty thousand dollars.

For two drawkeepers for Navy Yard and Upper bridges, one thousand four hundred and forty dollars.

For watchman in Franklin Square, six hundred and sixty dollars.

For watchman in Lafayette Square, six hundred and sixty dollars.

For three watchmen in Smithsonian grounds, at six hundred and sixty dollars each, one thousand nine hundred and eighty dollars.

For one watchman for Judiciary Square, and one for Lincoln Square and adjacent reservations, at six hundred and sixty dollars each, one thousand three hundred and twenty dollars.

For one bridgekeeper at Chain Bridge, six hundred and sixty dollars.

For contingent and incidental expenses, five hundred dollars. Contingencies.

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Approved, June 19, 1878.

CHAP. 350.—An act making appropriations for sundry civil expenses of the government for the fiscal year ending June 30, 1879, and for other purposes. June 20, 1878.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the following sums be, and the same are hereby, appropriated for the objects hereinafter expressed for the fiscal year ending June thirtieth, eighteen hundred and seventy-nine, namely: Appropriations. Sundry civil expenses.

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UNDER THE WAR DEPARTMENT.

* * * * * * *

BUILDINGS AND GROUNDS IN AND AROUND WASHINGTON AND THE EXECUTIVE MANSION.

Improvement and care of public grounds: For filling in and improving grounds south of Executive Mansion five thousand dollars. Public grounds in Washington, D. C.

For ordinary care of greenhouses and the nursery, one thousand five

Proviso. What to be propagated.

hundred dollars: *Provided*, That hereafter only such trees, shrubs, and plants shall be propagated at the greenhouses and nursery as are suitable for planting in the public reservations, to which purpose only the said productions of the greenhouses and nursery shall be applied.

For ordinary care of Lafayette Square, one thousand dollars.

For care and improvement of reservation number three (Monument grounds), one thousand dollars.

For annual repair of iron fences, five hundred dollars.

For manure, and hauling the same two thousand five hundred dollars.

Public grounds in Washington, D. C.

For painting iron fences, vases, lamps, and lamp-posts, one thousand five hundred dollars.

For purchase and repair of seats, one thousand dollars.

For purchase and repair of tools, five hundred dollars.

For trees, tree-stakes, lime, whitewashing, and stock for nursery, two thousand dollars.

For removing snow and ice, one thousand dollars.

For flowers, pots, twine, baskets, and lycopodium, five hundred dollars.

For abating nuisances, five hundred dollars.

For care and repair of fountains in the public grounds one thousand dollars.

For improving various reservations five thousand dollars.

Executive Mansion.

For laborers employed in the public grounds, four thousand dollars.

Executive Mansion: For care of and repairs, refurnishing, and fuel for the Executive Mansion, and care of and necessary repair to the greenhouses, and fuel for the same, twenty-five thousand dollars.

Bridges.

For care and repair of bridges, one thousand dollars.

Lighting, etc.

Lighting the Executive Mansion and public grounds: For gas, pay of lamplighters, gas fitters, plumbers, plumbing, lamps, lamp-posts, matches, and repairs of all kinds; lamps for Anacostia bridge; fuel for the office, watchmen's lodges, and for the greenhouse in the nursery, fifteen thousand dollars: *Provided*, That no more than twenty-five dollars shall be paid per street-lamp for gas; and in case a contract cannot be made at that rate, the engineer in charge is hereby authorized to substitute other illuminating material, and to use so much of the sum hereby appropriated as may be necessary for that purpose.

Proviso. Price of gas.

Water-pipes, etc.

Repair of water pipes and fire-plugs: For repairing and extending water-pipes, purchase of apparatus to clean them, and for cleaning the springs and repairing and renewing the pipes of the same that supply the Capitol, the Executive Mansion, and the War and Navy Departments, two thousand dollars.

Department telegraph.

Telegraph to connect the Capitol with the departments and the Government Printing Office: For repair and care of the same, one thousand dollars.

Washington aqueduct.

Washington aqueduct: For engineering, maintenance, and general repairs of the same, fifteen thousand dollars.

State, War, and Navy Department building.

Building for State, War, and Navy Departments (east wing): To complete the east wing and its approaches, to be expended for plastering and stucco, glazing, painting, carpenter and joiner work, tiling floors, mantels and grates, elevators, balusters for winding-stairways, iron fence, lamp-posts and lanterns for the approaches, office rent, and contingencies, three hundred and twenty-five thousand dollars.

For continuing the construction of the north wing, to be expended for cut-stone, excavations, and foundations, two hundred and fifty thousand dollars.

Statue of General Thomas. 1876, ch. 246, 19 Stat., 114.

That the unexpended balance of the appropriation for the statue of General George H. Thomas, made by the act of July thirty-first, eighteen hundred and seventy six, amounting to two thousand four hundred and sixty-five dollars and fifteen cents, be, and the same is hereby reappropriated, and made available to finish the pedestal and statue.

MISCELLANEOUS OBJECTS.

Geographical survey.

One hundredth meridian: For continuing, in field and office, the geographical survey of the territory of the United States west of the one hundredth meridian, the supply branches of the War Department aiding as heretofore; for the preparation, engraving, and printing of the maps and other illustrations, and the purchase of locations for connecting-stations, fifty thousand dollars; to be immediately available.

Survey of Northern and Northwestern lakes, etc.

Survey of Northern and Northwestern Lakes and Mississippi River: For continuing survey of Lake Erie: determination of points in aid of State surveys and construction of maps, continuation of triangulation

east from Mungo and south from Chicago and east to Lake Erie, survey of the Mississippi River; for Lake Erie: completion of triangulation and measurement of base, constructing and engraving maps; for Lake Ontario; for Lake Michigan: continuation of triangulation east from Mungo and south from Chicago, and publication of maps; for survey of the Mississippi River: continuation of triangulation, continuation of topography and hydrography, continuation of levels, purchase of steam-launches and quarter-boats, and reduction of work and construction and publication of maps; water-level observations; quarters and fuel for officers; determination of points in aid of State surveys; office rent fuel; stationery; instruments; and for miscellaneous purposes incident to the work, ninety-nine thousand dollars; one half of which shall be used in continuing the survey, now being made under direction of the War Department, of the Mississippi River and tributaries.

Hartford and New York Steamboat Company.

To enable the Secretary of War to pay to the Hartford and New York Steamboat Company for dredging done in the Connecticut River, under the direction of Major G. K. Warren, United States Engineers, in the months of July, August, and September, eighteen hundred and seventy-six, four thousand two hundred and three dollars.

G. F. Wheeler R. H. Hotchkiss, A. Walters. 1875, ch. 166, 18 Stat., 506.

For payment of George F. Wheeler, Robert H. Hotchkiss and Aaron Walters, for services rendered by them as commissioners appointed pursuant to an act of Congress of March third, eighteen hundred and seventy-five, to appraise damages to lands in Fond du Lac County Wisconsin, caused by the improvement of the Fox and Wisconsin Rivers, five thousand three hundred and ten dollars.

* * * * * * *

James B. Eads.

The requisite amount is hereby appropriated, out of any money in the Treasury not otherwise appropriated, to pay all money that may become due and owing to James B. Eads and his associates, or that may become payable to said Eads, his assigns or legal representatives, in accordance with the provisions of the act approved March third, eighteen hundred and seventy-five, and the act amendatory thereof, prior to the first day of February, eighteen hundred and seventy-nine.

1875, ch. 134, 18 Stat., 463.
1878, ch. 313, *ante*, p. 168.

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Free wagon-bridge at Fort Snelling.

That the sum of sixty-five thousand dollars be, and the same is hereby, appropriated, out of any money in the Treasury not otherwise appropriated, to aid in the construction and completion of a free wagon-bridge, with stone abutments, or stone and iron abutments, and iron superstructure, across the Mississippi River at or near Fort Snelling, between the military reservation of the United States upon which said fort is situated and a point nearly opposite said fort, in the county of Ramsey, Minnesota: *Provided*, That such bridge shall be constructed without the expenditure of any other or greater sum of money from the Treasury of the United States: *Prorided also*, That the height of said bridge shall be at least sixty-eight feet above high-water mark, and that a span of at least two hundred feet in the clear be provided from the right or Fort Snelling bank of said river toward the left bank thereof: *Provided further*, That said bridge shall be and forever remain, a public highway, free to the United States of America and to all the people thereof.

Proviso.
Cost.
Height and span.
Public highway.

Approval of plan, etc.

That the location of said bridge, and the plans, specifications, and estimates for the construction and completion thereof, shall be approved by the Secretary of War. And whenever the said bridge shall have been fully completed as hereinbefore provided, opened to travel, and irrevocably dedicated as a public highway, free to the United States of America and all the people thereof, the Secretary of the Treasury shall pay to the persons entitled to receive the same by reason of the construction of said bridge, or to the commissioners authorized to build said bridge, the said sum of sixty-five thousand dollars, which sum is hereby appropriated for said purpose: *Provided*, That said bridge, when constructed, shall be kept in good order and repair by the county of Ramsey, Minnesota; and the United States shall never be liable to any expense in the maintenance or repair of said bridge.

Payment, when to be made.

How to be kept in repair.

Authority to abut and make roads on reservation.

That the commissioners authorized to build said bridge under a special act of the legislature of Minnesota, entitled "An act to authorize and provide for the construction of a free bridge across the Mississippi River at or near Fort Snelling, and to lay out suitable roads and approaches thereto", approved March second, eighteen hundred and seventy-six, and the acts amendatory thereof, and their successors, be, and they are hereby, authorized to abut said bridge upon

the lands of the United States known as the Fort Snelling military reservation, and to construct and maintain an abutment thereon for said bridge, at such point as the Secretary of War shall approve, and to survey locate, open and maintain public roads or highways from said bridge; for which purpose a right of way not exceeding one hundred feet in width, from said bridge, across said military reservation, upon such line or lines as the Secretary of War shall direct or approve, is hereby given and granted to said commissioners and their successors.

* * * * * * *

National Academy of Sciences to consider and report plans of surveys.

And the National Academy of Sciences is hereby required, at their next meeting, to take into consideration the methods and expenses of conducting all surveys of a scientific character under the War or Interior Department, and the surveys of the Land Office, and to report to Congress as soon thereafter as may be practicable a plan for surveying and mapping the Territories of the United States on such general system as will, in their judgment, secure the best results at the least possible cost; and also to recommend to Congress a suitable plan for the publication and distribution of the reports, maps, and documents, and other results of said surveys, * * * * * *

Approved, June 20, 1878.

June 20, 1878.

CHAP. 361.—An act to appoint a commission to ascertain the cost of removing the Naval Observatory.

Naval Observatory. Commission to select site.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the President be, and he is hereby, directed to appoint, by and with the advice and consent of the Senate, a commission consisting of three persons, one of whom shall be a Rear Admiral of the Navy, one of whom shall be a Colonel of Engineers, and one shall be chosen from civil life, whose duty it shall be to select a site, within the District of Columbia, for the United States Naval Observatory, such site to possess relatively the advantages of healthfulness, clearness of atmosphere, convenience of access from the City of Washington, and such other advantages as may be found expedient, and to report fully thereon including estimates of the total expense of said site and the removal of the Observatory, to the next session of Congress: *Provided, however*, That no member of said commission shall be, directly or indirectly, interested, for himself, or for any other person, in any property to be selected as a site for said Observatory.

Report.

Proviso.

Proposals for sale of site.

SEC. 2. Said commission shall invite sealed proposals or offers of sale from the owners of land deemed fit for such a site, containing such provisions as they may deem sufficient to bind such owners to convey such land to the United States in case the same shall hereafter be selected and determined on as the site of said Observatory; which proposals shall be opened by the full commission publicly, and in the presence of persons interested who may choose to attend, on a day to be fixed for that purpose, after due notice to all parties interested; and no proposal received after such formal opening shall be opened or considered.

Sale of present site, etc.

SEC. 3. Said commission shall also consider and report upon the propriety and expediency of disposing of the old observatory grounds and buildings, the best and most advantageous method of selling the same, and the probable sum which may be realized therefore.

Examination of sites not offered.

SEC. 4. Said commissioners may, if they deem it necessary in order to secure the best site for said observatory examine any premises within said District not offered for sale as before provided which may seem eligible, and may report their estimate of the cash market value of the same

Approved, June 20, 1878.

Dec. 15, 1877.

[No. 2.] Joint resolution relative to reservoirs to promote the navigation of the Mississippi River.

Reservoirs on Saint Croix River, etc., examination for.

Be it resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That the Secretary of War be, and he is hereby, requested to make such preliminary examination of the headwaters of the Saint Croix, Chippewa, and Wisconsin Rivers, in the States of Minnesota and Wisconsin, as is consistent with his service,

to determine the extent and practicability of reservoirs upon the same, and report to this Congress the result of such examination, together with a compilation of all information and reports in his office bearing upon the subject of reservoirs, by February fifteenth proximo, or as early thereafter as practicable. And that he also report the estimated amount and character of the lands which would be submerged by such reservoirs.

Approved, December 15, 1877.

[No. 31.] Joint resolution to enable the joint commission to carry into effect the act of Congress providing for the completion of the Washington Monument.

June 14, 1878.

Be it resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That the joint commission created by the act of Congress entitled "An act providing for the completion of the Washington Monument", approved August second, eighteen hundred and seventy-six, be, and they are hereby, authorized to apply a portion of the money appropriated by said act not exceeding thirty-six thousand dollars to give greater stability to the foundation, if they deem it advisable.

Washington Monument.
Use of appropriation.
1876, ch. 250, 19 Stat., 123.

Approved, June 14, 1878.

APPENDIXES

TO THE

REPORT OF THE CHIEF OF ENGINEERS.

APPENDIXES

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APPENDIX A.

ANNUAL REPORT OF LIEUTENANT-COLONEL GEORGE THOM, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1878.

UNITED STATES ENGINEER OFFICE,
Portland, Me., July 12, 1878.

GENERAL: I have the honor to transmit herewith my annual reports of operations for the fiscal year ending June 30, 1878, on the several river and harbor improvements under my charge in the States of Maine, New Hampshire, and Massachusetts.

Very respectfully, your obedient servant,

GEO. THOM,
Lieut. Col. of Engineers, Bvt. Brig. Gen., U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

A 1.

IMPROVEMENT OF SAINT CROIX RIVER, ABOVE THE "LEDGE," MAINE.

The following appropriations have been made by Congress for the improvement of this river, viz:

By act approved March 2, 1867	$15,000 00
By act approved March 3, 1873	10,000 00
By act approved June 23, 1874	10,000 00
Total	35,000 00

The act of March 2, 1867, contains the proviso that—

The Province of New Brunswick contribute and pay to the proper disbursing officer a like sum for said purpose, said payment being made on condition that in no event shall the province of New Brunswick be called upon for more than half the sum actually expended for said purpose.

In July, 1873, information was received by the department from the minister of public works of the Dominion of Canada that $25,000 had been appropriated by Parliament—

For the removal of slabs, sawdust, and other obstructions in the Saint Croix River, which runs between the Province of New Brunswick and the State of Maine.

In 1873 an accurate survey was made under the direction of Lieut. Col. George Thom, Corps of Engineers, of this river from the "Ledge" up to the toll-bridge between Calais and Saint Stephen's, the head of navigation, a distance of about 5 miles, and a project for the improvement of this river, with an estimate of its cost, was submitted to both governments.

On referring to the estimate submitted to the department in the report on this survey, dated March 25, 1874, it is seen that about 235,000 cubic yards of slabs, edgings, &c., would have to be excavated in order to obtain a channel 200 feet wide and 9 feet deep at mean low-water (giving 29 feet at mean high-water) up to Todd's Ledge, and 100 feet wide with same depth, thence up to the toll-bridge, the estimated cost of which now is $150,000.

As these deposits in the channel have been caused solely by the saw-mills at Calais, Saint Stephen's, and above, and as there does not appear to be any law or authority strong enough to prevent the continuance of this evil, it has been decided by the two governments (see correspondence accompanying Lieutenant-Colonel Thom's annual report for the fiscal year ending June 30, 1874) to suspend this improvement until they shall become satisfied that there will be no more deposition of the "waste" from the saw-mills above, as otherwise there is no guarantee that the river, if now improved, would remain in a state of efficiency, but would probably be closed again and require further expenditure.

The attention of Congress is again respectfully asked to this matter, and to the necessity of some general law to protect from injury and obstructions all navigable waters under the control of the United States, and for the improvement of which Congress has already made, or may hereafter see fit to make, appropriations.

This river, throughout its whole extent, forms a part of the international boundary, and that portion of it for which improvements are projected lies within the collection-district of Passamaquoddy, the nearest port of entry being at Calais, Me.

The light-house nearest thereto is at Dochet's Island, in the Saint Croix River, about 8 miles below Calais, and the nearest fort is Fort Sullivan, at Eastport, Me., about 30 miles below Calais.

The following information in regard to the revenue and commerce of the port of Calais, for the year ending December 31, 1877, has been furnished by the United States deputy collector of customs, viz:

Amount of revenue collected, $10,614. Vessels arrived, 925 coastwise and 52 foreign. Vessels cleared, 921 coastwise and 59 foreign. Vessels built, 1 ship, 1 bark, and 1 schooner, aggregating 2,324.90 tons. Vessels owned in Calais, 85, aggregating 11,584 tons. River open to navigation 282 days.

Money statement.

July 1, 1877, amount available	$34,000 00
July 1, 1878, amount available	34,000 00

A 2.

IMPROVEMENT OF PENOBSCOT RIVER, MAINE.

The work that has been projected for the improvement of this river consists—

1. In straightening, deepening, and widening its channel through the several shoals and bars at Bangor, and below for a distance of 3½ miles,

so as to have a width of not less than 200 feet, and a depth of not less than 11 feet at low-water (or 25 feet at high-water) in the *lowest* stages, giving about 14 feet of water at low-water in its *ordinary* stages.

2. In breaking up and removing all the sunken ledges and bowlders in the harbor of Bangor, outside the main channel, down to the level of the general bed of the river, including Independence Rock, Gulliver's Rock, the ledge near steamboat wharf, and those near Dole's wharf, Green's Pier and Green's Pier Ledge, and a ledge outside of it, also the bowlders and ledges in front of the wharves at High Head.

The following appropriations have been made by Congress, to date, for the improvement of this river, viz:

By act approved July 11, 1870	$15,000 00
By act approved March 3, 1871	50,000 00
By act approved June 10, 1872	40,000 00
By act approved March 3, 1873	20,000 00
By act approved June 23, 1874	20,000 00
By act approved March 3, 1875, which provides that $10,000 of this amount shall be expended at or near Bucksport Narrows, for which no project or estimate has been made	25,000 00
By act approved August 14, 1876, which provides that $4,000 of the amount shall be expended at or near "The Narrows" of said river at Bucksport.	10,000 00
By act approved June 18, 1878, which provides that $2,500, or so much thereof as may be necessary, shall be expended at or near the Narrows in said river at Bucksport	12,000 00
Total	192,000 00

Of which amount $16,500 is chargeable to improvements at or near Bucksport Narrows (not estimated for), leaving only $175,500 available for the improvement of the river at and near Bangor (above Hampden), for which estimates have been submitted amounting to $184,000, leaving still necessary to be appropriated for completing all the works projected for the improvement of this river at and near Bangor, $8,500.

Of the total amount appropriated as above (to wit, $192,000), there had been expended on the 1st of July, 1877—

For improving the river at and near Bangor	$137,715 70
And at and near Bucksport, the sum of	10,000 00
Leaving then available for improvements at and near Bangor the sum of	18,284 30
And at and near Bucksport the sum of	4,000 00

The progress made in the improvement of this river up to the 1st of July, 1878, is as follows:

I.—AT AND NEAR BANGOR.

1. *Dredging.*—Under the several contracts made for dredging at and near Bangor (as specified in last annual report), amounting in the aggregate to 105,234 cubic yards, all but 18,000 cubic yards had been completed at the close of the fiscal year ending June 30, 1877. This dredging was completed on the 26th day of September, 1877, by Mr. Augustus R. Wright, under his unfinished contract of May 13, 1875, making a total of 39,224 cubic yards of dredging done by him under that contract.

By these operations a safe and direct channel has been opened from "The Narrows," below Bangor, up to "The toll-bridge," a distance of about 3½ miles, having a width of not less than 200 feet, and a depth of not less than 11 feet at low tide in the lowest known stages of the river, or about 14 feet at low tide in its ordinary summer stages (when the average rise and fall of the tide is about 13 feet), with the exception of the small outcroppings of ledge about 2 feet shoal, situated about midway of the new channel at Bangor, at its western edge, the removal of which (in part) is now in progress, under contract.

2. *Removal of sunken rocks.*—Independence Rock and Gulliver's Rock,

and the ledges near steamboat wharf, and those near Dole's wharf, and near (outside) Green's pier, Green's pier and the ledge upon which it rested, aggregating more than 2,000 cubic yards, had all been entirely broken up and removed on the 1st of July, 1877.

In the dredging operations of 1875 and 1876 numerous sunken ledges were discovered in and near the new channel at Bangor, requiring altogether the breaking up and removal of about 220 cubic yards of ledge, in order to obtain the projected depth of 11 feet at low water in the *lowest* stages of the river, the estimated cost of which was $12,000. Under the appropriation of $6,000 made for this work by act of August 14, 1876, a contract was made May 29, 1877, with Mr. Gardner Floyd, of Portland, Me., for the removal of 140 cubic yards, more or less, of this sunken ledge, at $39.75 per cubic yard, measured in its bed above the 11-foot plane. He commenced operations in the latter part of June, 1877, and continued them until the latter part of October, when, owing to the freshet in the river, and the consequent disturbed condition of the water, he was obliged to suspend work for the winter, during which period he had broken up and removed about 70 cubic yards of ledge under his contract. This work was resumed by him on the 20th of June, 1878. It is probable that he will complete his contract before the end of the present working season.

During the past year surveys have been made with a view to the improvement of the harbor in front of High Head wharves and at the mouth of Kenduskeag stream; and, on the 12th of January, 1878, a report on the survey at High Head was made to the department, with an estimate and drawing of the projected improvement at that place, a copy of which is hereto attached, marked A.

The following is an amended estimate of the cost of the work that remains to be done for completing the improvement of this river as now projected, to wit:

1. Breaking up and removing sunken ledge in new channel at Bangor, not yet contracted for, including contingencies, say	$6,000 00
2. Deepening channel in front of High Head wharves, as per estimate in accompanying report	12,000 00
Total	18,000 00
Amount now available for the above	12,000 00
Additional amount required for completing all the work now projected for improving the harbor of Bangor	6,000 00

II.—AT AND NEAR BUCKSPORT NARROWS.

By the act of March 3, 1875, making an appropriation of $25,000 for the improvement of Penobscot River, it was provided that $10,000 of it should be expended "at or near Bucksport Narrows," 18 miles below Bangor. This appropriation was applied to the partial removal of the shoal known as the Middle Ground, in front of the town of Bucksport. This shoal had, in some places, but 4 feet of water at mean low-water, and was a serious obstruction to navigation. Under a contract made July 16, 1875, with Messrs. Curtis, Fobes & Co., of Portland, Me., the lowest of two bidders, the upper portion of this shoal was removed in 1875 to a depth of 12 feet at mean low-water, or 22.3 feet at ordinary high-water.

Under the act of August 14, 1876, by which an additional sum of $4,000 was to be applied to the improvement of the river "at or near the Narrows" at Bucksport, a contract dated June 1, 1877, was made

with Mr. Augustus R. Wright for 12,000 cubic yards, more or less, of dredging on the remaining part of the Middle Ground, so as to have a depth of not less than 8 feet at mean low-water, the work to be completed not later than the 30th day of November, 1877. This contract was completed on the 31st of October, 1877, with 11,024 cubic yards of dredging, making a total of 72,934 cubic yards of dredging under both contracts.

The following information in regard to the revenue and commerce of the port of Bangor, for the year ending December 31, 1877, has been furnished by the United States collector of customs at that place, viz:

Amount of revenue collected, $4,244; value of imports, $9,772; value of exports, $28,796. Number of arrivals (foreign and domestic), about 2,000 vessels. Departures the same, of which 46 arrived from foreign ports, and 120 cleared for foreign ports; all others coastwise. Number of vessels built, 6; aggregate tonnage, 2,463.16.

Money statement.

July 1, 1877, amount available	$22,284 30	
Amount appropriated by act approved June 18, 1878	12,000 00	
		$34,284 30
July 1, 1878, amount expended during fiscal year	18,786 57	
July 1, 1878, outstanding liabilities	477 00	
		19,263 57
July 1, 1878, amount available		15,020 73
Amount (estimated) required for completion of existing project		6,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		6,000 00

SPECIAL REPORT ON THE IMPROVEMENT NEAR HIGH HEAD WHARVES, IN THE HARBOR AT BANGOR, MAINE.

UNITED STATES ENGINEER'S OFFICE,
Portland, Me., January 12, 1878.

GENERAL: In compliance with the wishes of some of the citizens of Bangor, Me., who are most interested in the commerce of that city, I have made an investigation as to the practicability and cost of improving the harbor near High Head wharves, so as to make it available and safe for vessels of the largest class (drawing about 21 feet, loaded) which now frequent that port for freighting lumber, &c., to foreign ports.

High Head wharves are at the lower end of the harbor, about one mile below the toll-bridge. This is the only part of the harbor where vessels of the largest class, above referred to, can float at low-water, and which is used for such trade—the depth of the channel being about 18 feet at low-water in the lowest known stages of the river, or about 21 feet at low-water in its ordinary summer stages; the ordinary rise and fall of the tide being 13 feet. These wharves extend into the river as far as the established harbor-lines, and have a depth immediately in front of them ranging from 3 feet at their upper end (at the point marked "a") to 18 feet at the lower end (at the point marked "d"), at *extreme* low-water, as shown on the accompanying drawing;* the upper part being shoaled chiefly by outcroppings of ledge and the lower part by gravel and occasional bowlders.

To make this part of the harbor available and safe for vessels of the

* Drawing on *file in office of the Chief of Engineers*, U. S. A.

largest class would require, as ascertained from a very accurate survey recently made—

215 cubic yards of rock-excavation, at an estimated cost of	$8,600
About 1,450 cubic yards of dredging (gravel and bowlders), at an estimated cost of	2,175
Adding for contingencies, say	1,225
Total cost	12,000

This would increase the depth in front of the harbor-lines so as to give, in the *ordinary* stages of the river—

1. From the upper end of the wharf at "a" down to "b" (a distance of 275 feet), 12 feet at low water;
2. Thence to point marked "c" (an additional distance of 150 feet), 15 feet at low water; and
3. Thence to the lower corner at "d" (an additional distance of 375 feet), 21 feet at low water.

These depths might possibly be 3 feet less when the river is in its very lowest stages, which would be of very rare occurrence.

This, in my opinion, is a much-needed improvement, and in view of the comparatively small cost of the work, as above estimated, it is respectfully recommended that it be taken in hand at as early a day as practicable; for which purpose an appropriation of $12,000 will be required in addition to the sum of $6,000 asked for in my last annual report for completing the removal of the sunken ledges about midway of the new channel at Bangor, making a total of $18,000.

Very respectfully, your obedient servant,

GEO. THOM,
Lieutenant-Colonel of Engineers, Brevet Brig. Gen., U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

A 3.

IMPROVEMENT OF BELFAST HARBOR, MAINE.

This harbor is situated in the northwest part of Penobscot Bay, and is well protected from all winds except those from the southeast. To render it safe from those winds, a breakwater would be required, and for this work a plan and estimate were submitted by Lieutenant-Colonel Thom, in his report of December 9, 1875, upon the survey made by him with a view to the improvement of Belfast Bay and Harbor, which report is found in his annual report for the year ending June 30, 1876.

The harbor is also obstructed by a shoal on its west side, extending from McGilvery's ship-yard up to Lane's wharf, a distance of about five-eighths of a mile. This shoal lies in front of the Boston, Portland and Bangor steamboat-wharves, and in places has but 6 feet of water over it at mean low-water, while the commerce of this city requires a depth of 12 feet at mean low-water, to enable the steamers and other vessels that frequent its harbor to enter and lie there in all stages of the tide.

Under the appropriation of $5,000 made by act of August 14, 1876, for the improvement of this harbor, a contract was made with Mr. James M. Andrews, of Biddeford, Me., for the removal of the outer portion of the shoal in front of Lane's wharf to the projected depth of 7 feet at mean low-water, which was completed by him in November last.

So that the work that now remains to be done for completing the

nent of this harbor by the removal of its shoals to the projected 12 feet at mean low-water consists of—

bic yards of dredging of soft mud, the estimated cost ofwhich, its per cubic yard, is	$23,000 00
cubic yards of hard dredging, at $1 per cubic yard	4,000 00
r contingencies	3,000 00
al additional amount required for completing this improvement	30,000 00

Congress approved June 18, 1878, there has been appropriated work the sum of 12,000 00
ere is now required for its completion the additional sum of.... 18,000 00

llowing information in regard to the commerce and revenue of of Belfast, for the year ending December 31, 1877, has been d by the United States collector of customs at that port:

of revenue collected, $3,385.74; value of exports, $7,655.20; value of im-77.25; arrivals of vessels from foreign ports, 18; arrivals of vessels coast-5; departure of vessels for foreign ports, 22; departure of vessels coastwise, mber of vessels built in the district, 9; aggregate tonnage of same, 4,829.08. siness of the year ending December 31, 1877, is much less than the average st ten years. The importing business has been in a great part suspended, building also.

rbor of Belfast is within the collection-district of Belfast.

ht-houses nearest thereto are on Dice's Head, near Castine, and on Fort Point, it 10 miles from Belfast; and the nearest fort is Fort Knox, opposite Bucks-nt 18 miles from Belfast.

Money statement.

77, amount available	$4,991 00	
appropriated by act approved June 18, 1878	12,000 00	
		$16,991 00
78, amount expended during fiscal year		4,959 04
78, amount available		12,031 96
(estimated) required for completion of existing projects		18,000 00
hat can be profitably expended in fiscal year ending June 30, 1880.		18,000 00

A 4.

IMPROVEMENT OF KENNEBEC RIVER, MAINE.

following appropriations have been made by Congress for the ement of this river, viz:

pproved June 23, 1866	$20,000 00
pproved March 2, 1867	30,000 00
under act approved April 10, 1869	15,000 00
pproved July 11, 1870	15,000 00
pproved March 3, 1871	15,000 00
pproved June 10, 1872	8,000 00
pproved March 3, 1873	12,000 00
pproved June 23, 1874	12,000 00
pproved March 3, 1875	15,000 00
tal	142,000 00

he improvements projected for this river *above* Richmond, Me., mpleted prior to June 30, 1874, as described in Lieut. Col. George annual report for the fiscal year ending that date, whereby a d unobstructed channel not less than 100 feet in width, and 10 depth at mean low-water or 15½ feet at mean high-water in its mmer stages, had been completed from Richmond up to Gardiner, nce of 11 miles; *and thence to Augusta, a distance* of 6 miles, a

channel 100 feet in width and not less than 6½ feet in depth at low-water, or 11 feet at high-water, in its lowest summer stages. This improvement included the removal of a very dangerous ledge, known as Nehumkeg Rock (between Richmond and Gardiner), to a depth of 12 feet below mean low-water; and on the 30th of June, 1875, all the projected improvements *below* Richmond (including the removal of "Half Tide Rock" and three other sunken ledges from "The Narrows") were completed, with the exception of the removal of Dry Rock in "The Narrows."

On the 6th of May, 1875, a contract was made with Mr. Isaac Hamilton, of Portland, Me., the lowest of five bidders, for removing Dry Rock (containing about 1,775 cubic yards,) at $15 per cubic yard, as measured in its bed, so as to have over it a depth of 12 feet at mean low-water. Work was commenced under this contract on the 2d of June, 1875, and was continued up to the 20th of November, 1875 (when it was suspended on account of freshets and ice), and again resumed on the 2d of June, 1876, and continued up to the 8th of November, 1876, when about 1,100 cubic yards had been removed. It was then again suspended for the winter on account of freshets and ice, and was resumed on the 30th of May, 1877. Up to July 1, 1877, about 1,230 cubic yards were removed to the required depth, leaving only 545 cubic yards to be removed. This work was completed on the 12th of September, 1877.

All the work projected for the improvement of this river has been completed, so that no further appropriations will be needed therefor.

These improvements, as above described, are located in the collection-district of Bath, Me., in which Bath (30 miles below Augusta) is the only port of entry.

Fort Popham is at the mouth of Kennebec River, about 45 miles below Augusta, and the United States "Kennebec Arsenal" is located at Augusta.

Seguin and Pond Island light-houses are near the mouth of Kennebec River.

The following information in regard to the commerce and revenue of the port of Bath for the year ending December 31, 1877, has been furnished by the United States collector of customs at that port:

Amount of revenue collected		$19,090 03
Value of exports		130,765 00
Value of imports		81,018 00
	Number.	Tons.
Coastwise arrivals	1,429	291,186
Coastwise departures	1,433	311,058
Foreign arrivals	22	9,495
Foreign clearances	25	6,688
Number of vessels built in the district		48
Aggregate tonnage of same		32,688

Money statement.

July 1, 1877, amount available	$9,489 56
July 1, 1878, amount expended during fiscal year	9,489 56

A 5.

IMPROVEMENT AT THE "GUT" OPPOSITE BATH, MAINE.

The following appropriations have been made by Congress for improving the navigation of this place, viz:

By act approved July 11, 1870	$10,000 00
By act approved March 3, 1871	6,500 00
By act approved June 18, 1878	17,000 00
Total	33,500 00

The work projected to be done with the appropriations made in 1870 and 1871, as above, was completed in 1872, and consisted of the following, viz:

1. The removal of Boiler Rock to a depth of 10 feet at mean low-water, or 16½ feet at mean high-water.

2. The removal to a depth of 9 feet at mean low-water of the ledge extending from Boiler Rock northward toward the shore.

3. The removal of two wrecks of vessels lying in mid-channel above and near Upper Hell Gate.

4. Dredging a channel through the bar next above Upper Hell Gate to a width of 100 feet and a depth of 10 feet at mean low-water, or 16½ feet at mean high-water.

5. The breaking up and removal of points of ledge which projected into the river from its southern shore at the Upper Hell Gate (amounting altogether to about 1,000 cubic yards), whereby the water-way was increased from a width of about 100 to about 150 feet.

By these operations the channel at the Upper Hell Gate was deepened and straightened, and the current much diminished in velocity.

The additional work that is now projected to be done under the appropriation of June 18, 1878, consists of the following (as stated in my special report to the department, dated February 21, 1878, a copy of which is hereto attached), viz:

1. For dredging shoal above Upper Hell Gate to a depth of 12 feet at mean low-water, 20,000 cubic yards, at 30 cents per cubic yard	$6,000 00
2. Widening the passage through Upper Hell Gate by 1,000 cubic yards of ledge excavation, at $4 per cubic yard	4,000 00
3. Breaking up and removing 160 cubic yards of sunken ledge from the channel on the north and east side of Marsh Island, at $35 per cubic yard	5,600 00
For engineering expenses and other contingencies, say	1,400 00
Total	17,000 00

This work, it is believed, can be accomplished with the amount last appropriated, so that no further appropriation is deemed necessary for the improvement of this place.

The locality of the proposed improvement is in the collection-district of Bath, Me. Bath is the only port of entry in the collection-district, and is distant from the Upper Hell Gate about 3 miles. The nearest light-houses are Seguin and Pond Island, near the mouth of Kennebec River, and the nearest fort is Fort Popham, at the mouth of Kennebec River, distant about 15 miles.

Money statement.

Amount appropriated by act approved June 18, 1878	$17,000 00
July 1, 1878, amount available	17,000 00

SPECIAL REPORT ON IMPROVEMENT AT THE "GUT" OPPOSITE BATH, MAINE.

UNITED STATES ENGINEER OFFICE,
Portland, Me., February 21, 1878.

GENERAL: I have the honor to acknowledge the receipt of department letter of the 15th instant, furnishing for my information and a report the resolution of the House of Representatives, of February 13, 1878, calling upon the honorable Secretary of War for "information as to the necessity of *further improvement to the 'Gut'* opposite Bath, Me.,

and the amount of appropriation required for that purpose, said locality having heretofore been surveyed," and, in compliance therewith, to report as follows:

"The Gut," so called, is a part of Back River, which is a tidal river about 9 miles in length connecting the Kennebec River at Bath, Me., with the tidal waters of the Sheepscot River to the eastward of it. It is navigable for small steamers and other vessels of light draught, and affords a short communication between the Kennebec River and the towns of Westport, Wiscasset, Boothbay, Southport, and other places on and near the waters of the Sheepscot. At "the Gut" (or more commonly called the "Upper Hell Gate"), which is about two miles distant from the city of Bath, the navigation of this river has already been very much improved in its most difficult places under appropriations made therefor, by Congress, in 1870 and 1871, amounting to $16,500. On referring to my annual report of 1873, it will be seen that these appropriations have been applied to—

1. The breaking up and removal of Boiler Rock (a large and very dangerous rock in mid-channel at the Upper Hell Gate), so as to have a depth of 10 feet at mean low-water, or 16½ feet at mean high-water.
2. The breaking up and removal of a ledge between Boiler Rock and the north shore, to a depth of 9 feet at mean low-water.
3. The removal of two wrecks of vessels lying in mid-channel above and near Upper Hell Gate.
4. Dredging a channel through the bar next above Upper Hell Gate to a width of 100 feet, and a depth of 10 feet, at mean low-water, or 16 feet at ordinary high-water.
5. The breaking up and removal of points of ledge which projecte into the river from its southern shore at the Upper Hell Gate, whereb its water-way has been much increased, and the velocity of the current much diminished. This work was completed in 1872; and the improvements have benefited the commerce and navigation of this river to such an extent, and have given such an impetus thereto, that those who are interested therein are now very desirous of having more work done for its further improvement, as follows, viz: 1st, to have the shoal next above Upper Hell Gate excavated to a depth of 12 feet at mean low water; 2d, to have the passage through Upper Hell Gate opened to still greater width so as to diminish the velocity of the current; and 3d, to have some projecting points of ledges and sunken rocks below Boiler Rock broken up and removed so as to render safe and practicable the direct channel on the northward and eastward of Marsh Island and thereby avoid the present crooked channel south of the island.

In the absence of special surveys to ascertain with great accuracy the extent and probable cost of this additional work for the further improvement of this river at the Gut (so called) opposite Bath, Me., the following approximate estimate of cost is submitted, viz:

1. For dredging shoal above Upper Hell Gate to a depth of 12 feet at mean low-water, 20,000 cubic yards, at 30 cents per cubic yard	$6, 000
2. Widening the passage through Upper Hell Gate, 1,000 cubic yards of ledge excavation, at $4 per cubic yard	4, 000
3. Breaking up and removing 160 cubic yards of sunken ledge from the channel on the north and east side of Marsh Island, at $35	5, 600
4. For engineering expenses and other contingencies, say	1, 400
Total	17, 000

On making inquiry of those who are best informed in regard to the nature and extent of the navigation and commerce of this river and to what extent the public interests would be benefited by the further im

provement of the river as proposed, the following information has been received, viz: "This is the principal route of travel to and from the towns of South Bristol, Boothbay, Southport, Westport, and Georgetown. The growth of the oil and fishing business has added largely, during the past ten years, to the population and business of these towns, more especially to Bristol and Boothbay; and the latter place is now extensively resorted to by pleasure travelers in the summer season. The Eastern Steamboat Company has for several years run a line of boats between Bath and Boothbay, running two steamers daily during the summer season, and one daily for the rest of the year. Their business amounts to 20,000 to 22,000 passengers each season, and the principal mail goes by them. During the summer months a steamer runs from Augusta to Boothbay by this route. Coasting-vessels bound east from the Kennebec, if not of too large size, use this passage, as it lessens the distance very materially. All the traffic between the towns on the Kennebec and those mentioned above, which is very considerable, goes by this route.

The large lumber mills at Wiscasset and Westport are supplied with logs from the Kennebec, which all go through Hell Gate passage by means of tug-boats.

Very respectfully, your obedient servant,

GEO. THOM,
Lieut. Col. of Engineers, Brt. Brig. Gen., U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

A 6.

IMPROVEMENT OF PORTLAND HARBOR, MAINE.

Under appropriations amounting to $61,336, made by acts of Congress in the years 1836, 1837, and 1838, for the improvement of this harbor, a stone breakwater was built on Stanford's Ledge for a length of 1,763 feet, of which 1,030 feet only was capped and completed.

For completing this breakwater and all the other projected improvements of this harbor, the following additional appropriations have since been made, viz:

By act approved June 23, 1866	$105,111 05
By act approved July 11, 1870	10,000 00
By act approved March 3, 1871	40,000 00
By act approved June 10, 1872	45,000 00
By act approved March 3, 1873	50,000 00
By act approved June 23, 1874	20,000 00
By act approved March 3, 1875	20,000 00
Total	290,111 05
Of which there has been expended up to July 1, 1878, the sum of	248,202 67
Leaving available the sum of	41,908 38

Under the appropriations made from 1866–'75, the following additional work has been done to date, for the improvement of this harbor, viz:

1. The breakwater has been extended for a length of 217 feet, and a granite pier 25 feet in diameter built at its outer extremity, and 950 linear feet of capping placed upon the breakwater in completion of same. This breakwater has now a total length (*including its* terminal pier) of 2,005 feet.

2. A channel has been dredged through the Middle Ground Bar to a width of 500 feet, and to a depth of 21 to 22 feet at mean low-water, or 31 feet at ordinary high-water.

3. A channel has been dredged through the "spit" in front of the Grand Trunk Railway wharves to a width of 100 feet at its inner end and 200 feet at its outer end, and to a depth of 20 feet at mean low-water.

4. A channel has been dredged in Back Bay from Tukey's bridge up to the "Stone-shed wharves" to a width of 100 feet and a depth of 8 feet at mean low-water.

5. A sunken wreck has been removed from the main ship-channel between Forts Preble and Scammel.

6. The foundation of the oldest portion of the breakwater has been repaired throughout its whole extent where necessary.

7. All the projected dredging in front of the Grand Trunk Railway wharves has been completed to a depth of 20 feet at mean low-water, and all that in front of the harbor commissioners' line from Atlantic Wharf up to Merrill's wharf to a depth of about 16 feet at mean low-water.

8. The dock at Custom-house Wharf has been deepened by 2,932 cubic yards of dredging, the same having been authorized by the department upon the request of the honorable Secretary of the Treasury.

The total quantity of dredging thus far done for the improvement of this harbor amounts to 370,024 cubic yards.

All the work that has been projected for the improvement of this harbor has been completed, with the exception of about 100,000 cubic yards of dredging outside the harbor commissioners' line above Merrill's wharf, for the completion of which the funds now available are sufficient, so that no further appropriation is needed for this harbor.

In regard to the dredging that remains to be done above Merrill's wharf outside the harbor commissioners' line, it has been decided to defer the work until Brown's, Boston and Maine (formerly Smith's), Hobson's, and other wharves which project beyond the harbor commissioners' line, shall have been cut off up to that line, for the reason that this work of improving the harbor in front of that line was initiated and recommended, and all the appropriations made therefor in 1873, 1874, and 1875, aggregating $90,000, have been asked for, with the understanding that those projecting wharves should first be removed in order to make the contemplated improvement effective and lasting; for so long as those wharves are permitted to project outside the harbor commissioners' line, so long will the eddies and shoals continue to exist above and below those wharves.

The above described works are situated in the collection district of Portland and Falmouth, Me.

The following information in regard to the commerce and revenue of the port of Portland and Falmouth for the year ending December 31, 1877, has been furnished by the United States collector of customs at that port:

Amount of revenue collected	$386,130 55
Value of imports	12,795,039 00
Value of exports	14,978,328 00

	Number.	Tons.	Crew.
Coastwise arrivals	742	635,403	13,361
Coastwise clearances	635	597,651	12,427
Foreign arrivals	402	179,327	4,952
Foreign clearances	302	220,243	5,819
Number of vessels built in the district			9
Aggregate tonnage of same			6,368

Money statement.

July 1, 1877, amount available	$42,930 10
July 1, 1878, amount expended during fiscal year	1,021 72
July 1, 1878, amount available	41,908 38

A 7.

IMPROVEMENT AT RICHMOND'S ISLAND, MAINE.

This work consists in making a harbor of refuge by means of a stone breakwater connecting the island with the mainland, the length of the breakwater to be about 2,000 feet, with an average thickness of 30 feet and a height of 13 feet above mean low-water.

In my report to the department, dated May 10, 1867, the following estimate of the cost of this breakwater was submitted:

68,000 tons of rubble-stone, at $1.25	$85,000 00
Adding 10 per cent. for contingencies	8,500 00
Total	93,500 00

A capping for this work was not estimated for on account of the great increase of cost; but, as then stated, should it hereafter be found necessary, in order to resist the action of the sea, which is not probable, it could be added.

The following appropriations have been made by Congress for this work, viz:

By act approved June 10, 1872	$20,000 00
By act approved March 3, 1873	60,000 00
By act approved March 3, 1875	15,000 00
By act approved June 18, 1878	6,000 00
Total	101,000 00

Under the appropriations made in 1872–'75, five separate contracts were made from time to time (as specified in the annual reports for the fiscal year ending June 30, 1876) for furnishing stone for this breakwater, by which 58,000 tons have been furnished and placed upon the work. With the appropriation of $6,000 made by act of June 18, 1878, it is probable that 4,000 tons of stone can be purchased and placed upon the work, so that to finish it as originally projected will require about 6,000 tons more, the estimated cost of which, including contingencies, is $9,000, thereby making the total cost of the work completed $110,000, which is $16,500 in excess of the original estimate. This excess is owing to the greater cost of the stone than was originally estimated, the quantity being the same.

Money statement.

Amount appropriated by act approved June 18, 1878	$6,000 00
July 1, 1878, amount available	6,000 00
Amount (estimated) required for completion of existing project	9,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880	9,000 00

A 8.

IMPROVEMENT OF KENNEBUNK RIVER, MAINE.

By an act of Congress of 1798 provision was made for keeping in repair a pier built at the mouth of this river for the improvement of its navigation, and by several subsequent acts, from 1829 to 1852, appropriations amounting to $44,175 were made for the further improvement of this river at and near its mouth.

These works consisted of—

1. A stone pier, about 600 feet in length, on the eastern side of the channel at the mouth of the river, with a light-house (since destroyed by storms) on its outer extremity, and a wooden catch-sand, about 160 feet in length, leading from the inner end of the pier to the eastern bank of the river. This pier and catch-sand served as a protection to the entrance from easterly storms, as well as to prevent the sand from being driven into the channel above.

2. A stone pier, about 290 feet in length, on the western side of the channel at the mouth of the river, with a wooden catch-sand, about 160 feet in length, leading from the inner end of the pier to the western bank of the river. This pier and catch-sand served a similar purpose on the western side of the river.

3. A crib-work wharf ballasted with stone, about 300 feet in length, built on the eastern side of the river, about one-eighth of a mile above its mouth, for the security of vessels while detained by tides and storms.

Since the completion of the above works, the following additional appropriations have been made by act of Congress for the improvement of this river, viz:

By act of July 11, 1870	$5,000
By act of March 3, 1871	5,000
By act of August 14, 1876	5,000
Total	15,000

Under the appropriation of 1870, the catch-sand or wing connecting the inner end of the pier with the eastern bank of the river, which had been destroyed by storms, was replaced by a permanent stone work, and some repairs were made where most necessary on the stone piers and on the wharf above.

Under the appropriation of 1871, the catch-sand or wing connecting the inner end of the western pier with the river bank, having also been destroyed by storms, it was replaced by a permanent stone work, and additional repairs were made on the piers and wharf.

Under the appropriation of $5,000 made by act of August 14, 1876, the following work has been done during the past fiscal year. This appropriation was based upon a project and estimate for deepening the channel of the river above the government wharf, at the "Wading Place" and at Mitchell's Point (where the most serious obstructions to its navigation were to be found), so as to have a depth of not less than 4 feet at mean low-water, or 13 feet at mean high-water. A contract was made June 7, 1877, for the dredging required at those two locations, with Messrs. George C. Fobes & Co., of Portland, Me., the lowest bidders, at 50 cents per cubic yard, which was completed by them on the 29th of September last, with 6,450 cubic yards of dredging. In addition to this work, extensive repairs have been made, where most necessary, on the stone piers at the mouth of the river as well as on the government wharf.

An accurate survey has also been made of the river in order to ascertain what, if any, additional work is necessary for the completion of its improvement to the extent demanded by the very large amount of ship building and other important business carried on in that river. This survey shows the necessity of the following additional work, viz:

1. The breaking up and removal to a depth of 4 feet at mean low-water of the sunken ledges near the mouth of Gooch Creek (marked A and B on the accompanying drawing*), as well as the sunken ledge below Ward's wharf (marked C on the drawing), aggregating 20 cubic yards, the estimated cost of which, at $35 per cubic yard, is	$700 00
2. Straightening, widening, and deepening the channel of the river by dredging at the shoals and points marked D, E, F, G, and H, on the accompanying drawing, aggregating about 7,600 cubic yards, the estimated cost of which, at 50 cents per cubic yard, is	3,800 00
3. Rebuilding of portions of the government wharf, and of the stone pier on the western side of the river at its mouth, say	800 00
Adding for contingencies, say	700 00
Total	6,000 00

This river lies within the collection district of Kennebunk, of which Kennebunk is the port of entry.

The following information as to the revenue and commerce of the port of Kennebunk, Me., for the year ending December 31, 1877, has been furnished by the United States collector of customs at that place, viz:

Amount of revenue collected, $787.18; number of arrivals and departures of foreign and domestic vessels, estimated at 100 each. Number of vessels built, 12, with an aggregate tonnage of 5,882.35, the largest of which measured 2,001.91 tons.

Money statement.

July 1, 1877, amount available	$4,992 00
July 1, 1878, amount expended during fiscal year	4,992 00
Amount (estimated) required for completion of existing project	6,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.	6,000 00

A 9.

IMPROVEMENT OF COCHECO RIVER, NEW HAMPSHIRE.

Cocheco River runs through the city of Dover, N. H., and 3 miles below to the lowest bridge. It unites with the Salmon Falls River, and forms the Piscataqua River, from which point down to its outlet into Portsmouth Harbor, New Hampshire, a distance of about 9 miles, the Piscataqua River separates the States of Maine and New Hampshire.

The Piscataqua and Cocheco Rivers are navigable, in their lowest summer stages, with not less than 6 feet of water at mean low-water, or about 13 feet at mean high-water, from Portsmouth Harbor up to the foot of the Lower Narrows in Cocheco River, distant about 1½ miles below the lowest bridge at Dover. At the Lower Narrows and above, navigation has been much impeded by ledges, bowlders, and shoals, having from 6 inches to 2 feet only of water on them at mean low-water, the average rise and fall of the tides being about 7 feet at the Lower Narrows.

The original project for the improvement of this river, based on an examination made in 1870, consisted of making a channel not less than 40 feet in width and 4 feet in depth, at mean low-water, from the

*Drawing forwarded on separate roll.

foot of the Lower Narrows up to Collins's wharf (at the head of the l per Narrows), the estimated cost of which was $45,000, as shown in annual report of 1871. More accurate and extended surveys, si made, have shown the practicability and importance of extending t improvement up to the Packet Landing, the total estimate of which now amended, is $85,000.

The following appropriations have been made by Congress for improvement of this river, as now projected, viz:

By act approved March 3, 1871	$10,00
By act approved June 10, 1872	10,00
By act approved March 3, 1873	10,00
By act approved June 23, 1874	10,00
By act approved March 3, 1875	25,00
By act approved August 14, 1876	14,00
By act approved June 18, 1878	6,00
Total	85,00

Under the several appropriations made from 1871 to 1875, inclus contracts have been made from time to time, as stated in the last an report, whereby the following work has been done up to this date,

1. A channel has been opened through the ledge at the Upper rows for a length of 430 feet and to a width of 40 feet and a depth feet at mean low-water, or about 11 feet at ordinary high-water, re ing about 1,255 cubic yards of rock excavation.

2. A channel has been opened through the ledge next above Upper Narrows for a length of 260 feet and to a width of 40 feet a depth of 4 feet at mean low-water, requiring 1,108 cubic yards of e vation of ledge, bowlders, clay, &c.

3. The channel at and near the Lower Narrows has been nearly pleted by the removal of about 600 cubic yards of sunken ledge bowlders; and numerous scattered bowlders which were dangerou structions to navigation at Trickey's Shoal, Clements Point Shoal, elsewhere, have been broken up and removed.

4. The channel has been opened by dredging through the shoals existed between the Upper Narrows and Packet Landing, requi 7,108 cubic yards of dredging.

Under the appropriation of $14,000, made by the river and harbor a August 14, 1876, the following additional work has been done du the past fiscal year, viz:

A contract was made June 12, 1877, with the Atlantic Dredging C pany, of Brooklyn, N. Y., the lowest of three bidders, for the dred near the Packet Landing, at 49 cents per cubic yard, as measured i bed, and for the dredging at Clement's Point Shoal and below, a cents per cubic yard, as measured in the scows, and operations commenced at once by this company and continued until satisfact completed on the 23d of November last by 12,371 cubic yards of dr ing.

Under this contract all the projected dredging *above* the Upper rows has been completed, as well as at Clement's Point Shoal and be including a basin which has been excavated near Packet Landin a length of about 800 feet and an average width of 140 feet to a d of 4 to 5 feet at mean low-water (or about 11 feet at mean high-w in the lowest summer stage of the river. This basin furnishes the n sary room for the greatly increased commerce of this river, as we for the prospective additional trade, for which new wharf facilities recently been built.

Submarine work has also been carried on during the past yea

the removal of sunken ledges and bowlders at and near Clement's Point Shoal, Trickey's Shoal, the Upper and Lower Narrows, and at Dover Point, resulting in the breaking up and removal, altogether, of about 300 cubic yards of sunken rock. This work was completed in August last.

By the operations of the past year, all the work hitherto projected for the improvement of this river has been completed, with the exception of the excavation of the channel through the sunken rocks at Gulf Shoal next below the Upper Narrows, for which the funds now available will probably be sufficient.

Money statement.

July 1, 1877, amount available	$11,228 08	
Amount appropriated by act approved June 18, 1878	6,000 00	
		$17,228 08
July 1, 1878, amount expended during fiscal year		10,332 25
July 1, 1878, amount available		6,895 83

A 10.

IMPROVEMENT OF MERRIMAC RIVER, INCLUDING THE HARBOR OF NEWBURYPORT, MASSACHUSETTS.

The project for the improvement of this river consists in deepening its shoals by dredging and the removal of sunken rocks from its channel, so that it shall have a depth of 12 feet at ordinary high-water from its mouth in Newburyport Harbor, Massachusetts, up to Haverhill (a distance of 15 miles), and thence for a distance of about 4 miles up through "the falls," a depth of 4 feet in the ordinary stages of the river; and that for the improvement of Newburyport Harbor, in the removal of North and South Gangeway Rocks to a depth of 9 feet at mean low-water, the removal of "The Boilers" (sunken rocks near the city wharves) to a depth of 5 feet at mean low-water, and the removal of a sunken wreck.

The total estimated cost of all the work necessary for these improvements was $147,000, as specified in Lieutenant-Colonel Thom's last annual report, for which the following appropriations have been made by Congress, viz:

By act of July 11, 1870, for the improvement of Merrimac River, Massachusetts	$25,000 00
By act of March 3, 1871, for improvement of Merrimac River, above Haverhill, Mass	25,000 00
By act of June 10, 1872, for improvement of Merrimac River, above Haverhill, Mass	25,000 00
By act of March 3, 1873, for improvement of Merrimac River, Massachusetts	25,000 00
By act of June 23, 1874, for continuing the improvement of Merrimac River, Massachusetts	10,000 00
By act of March 3, 1875, for improvement of Merrimac River, Massachusetts	12,000 00
By act of June 18, 1878, for improving Merrimac River, Massachusetts, below Mitchell's Falls	10,000 00
Total	132,000 00
Of which amount there had been expended up to July 1, 1878, for improving this river and harbor the sum of	121,819 90
Leaving then available the sum of	10,180 10

The following work has been done to date, viz:

1.—FOR THE IMPROVEMENT OF THE RIVER ABOVE NEWBURYPORT.

The channel completed at Hazeltine Rapids, Lower Falls, and Upper Falls (above Haverhill, Mass.), so as to be navigable through "the falls" for a depth of 4 feet, in all stages of the river, except in an unusually low stage, resulting from shutting off the water at the Lawrence Mills on Sundays and at night. Shoals dredged and sunken bowlders removed from the channel at and near Rock's Bridge (6½ miles below Haverhill), including Little Currier Rock above and Petty Rock below the bridge, greatly improving this the most dangerous part of the river below Haverhill; the channel has been opened by dredging, for a width of 100 feet, to the projected depth, viz, 12 feet at ordinary high-water, at Currier's Shoal (distant about 5 miles below Haverhill); also to the same depth, and for a width of 75 feet, at the shoals near the head and foot of Silsby's Island, from 1 to 2 miles below Haverhill. The shoal between the two bridges at Haverhill has also been improved by dredging so as to have a channel 10 feet in depth at ordinary high-water, and numerous large bowlders have been removed from the channel at and near "the falls" above Haverhill.

During the past fiscal year about 80 tons of bowlders have been removed from the channel near the head of Silsby's Island, whereby it has been much improved.

2.—FOR THE IMPROVEMENT OF NEWBURYPORT HARBOR.

The main (south) Gangeway Rock broken up and removed to a depth of 9 feet at mean low-water, and a commencement made upon the removal of North Gangeway Rock, and the wreck of the schooner Globe also broken up and removed, leaving yet to be done the removal of North Gangeway Rock and "The Boilers."

The following is the estimated cost of the completion of the work now projected for the improvement of Newburyport Harbor, to wit:

1. Completing the removal of North Gangeway Rock to a depth of 9 feet below mean low water, say 360 cubic yards, at $40 per cubic yard	$14,400 00
2. For breaking up and removing "The Boilers" to a depth of 5 feet at mean low water, say 352 cubic yards, at $25 per cubic yard	8,800 00
Adding for contingencies, say	1,800 00
Total	25,000 00

The following information in regard to the revenue and commerce of the port of Newburyport, Mass., for the year ending December 31, 1877, has been furnished by the United States collector of customs at that place, viz:

Amount of revenue collected	$97,132 39
Value of exports	35,175 73
Value of imports	365,506 30
Number of vessels entered from foreign ports	29
Number of vessels cleared for foreign ports	26
Number of vessels entered from domestic ports	592
Number of vessels cleared for domestic ports	496
Number of vessels built	5
Aggregate tonnage of same	3,983.05

Money statement.

July 1, 1877, amount available	$1,251 10	
Amount appropriated by act approved June 18, 1878	10,000 00	
		$11,251 10
July 1, 1878, amount expended during fiscal year		1,071 00
July 1, 1878, amount available		10,180 10
Amount (estimated) required for completion of existing project		15,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		15,000 00

A 11.

IMPROVEMENT OF BOSTON HARBOR, MASSACHUSETTS.

The several works projected and commenced prior to 1866 for the improvement of Boston Harbor consisted of the sea-walls on Deer Island, Rainsford Island, Lovell's Island, and Great Brewster Island. The three on Deer Island were built under appropriations made therefor in 1825 to 1832, and were, for the most part, rebuilt in 1864–'69; that on Rainsford Island was built under the appropriations made therefor in 1836 and 1838; that on the north head of Lovell's Island was built in 1843, and that on the southeast bluff in 1868–'69; and that on Great Brewster Island was commenced in 1849 and completed in 1869.

It appears, on referring to the annual reports from 1866 to 1870, and to other records, that up to 1870 there had been expended for the sea-wall on Rainsford Island the sum of $22,353, and for those upon Deer and Lovell's Islands the sum of about $322,000, and for that on Great Brewster Island the sum of $269,000.

The sea-walls on Deer, Lovell's, and Great Brewster Islands were under the charge of Col. H. W. Benham from March, 1866, to March, 1873, when they were transferred to the charge of Lieut. Col. George Thom, Corps of Engineers.

In 1866 new works for the further improvement of this harbor were projected by the Board of Harbor Commissioners of the State of Massachusetts, for which they submitted the following estimate, to wit:

For the improvement of the channel across the Upper Middle Bar by dredging a channel 23 feet deep at mean low-water, and 1,000 feet wide, at a total estimated cost of	$157,085 00
For the improvement of the channel at the Narrows by dredging off the southwest point of Lovell's Island and the extremity of Great Brewster Spit, so as to widen the channel to 685 feet at 23 feet depth of water, at a total estimated cost of	188,805 00
For the improvement of the channel at the Narrows by blasting of Tower Rock and Corwin Rock, at an estimated cost of	20,000 00
For the preservation of the north head of Long Island by the construction of a sea-wall, at an estimated cost of	150,000 00
For the preservation of the north end of Gallop's Island, by the construction of a sea-wall, at an estimated cost of	103,585 63
For the preservation of Point Alerton, by the construction of a sea-wall, at an estimated cost of	70,991 87
Total	690,467 50

An appropriation based upon these estimates having been made by Congress in March, 1867, the late Lieut. Col. John G. Foster, Corps of Engineers, was assigned to the charge of those works in May, 1867, and they continued under his charge until May, 1871, when they were transferred to Lieut. Col. George Thom, Corps of Engineers.

For the several works projected as above in 1866, the following appropriations have been made by Congress to date, viz:

By act of March 2, 1867 (of which $75,000 was allotted to the sea-walls on Deer, Lovell's, and Great Brewster Islands)	$375,000 00
Under act of July 25, 1868 (of which $10,000 was allotted to the sea-wall on Great Brewster Island)	43,000 00
Under act of April 10, 1869	83,000 00
By act of July 11, 1870	100,000 00
By act of March 3, 1871	100,000 00
By act of June 2, 1872	75,000 00
By act of March 3, 1873	150,000 00
By act of June 23, 1874	100,000 00
By act of March 3, 1875, for the improvement of Boston Harbor, Massachusetts, $100,000, providing that of said amount $10,000 be expended for the improvement of Hingham Harbor, Massachusetts	90,000 00
By act of August 14, 1876	50,000 00
By act of June 18, 1878	55,000 00
Total	1,221,000 00
Of which amount there has been applied to sea-walls on Deer, Lovell's, and Great Brewster, Islands, as above	85,000 00

The following is a brief history of each of the works, completed and uncompleted, that have hitherto been projected for the improvement of this harbor (including works both prior and subsequent to those projected as above stated, in 1866), viz:

1.—SEA-WALL FOR THE PROTECTION AND PRESERVATION OF POINT ALBERTON.

Work was commenced on this wall in September, 1870, and was completed in May, 1874. It was built for the most part under four separate contracts with Mr. James M. Andrews, of Biddeford, Me., made, respectively, May 24, 1870; July 26, 1871; August 24, 1872; and May, 8, 1873.

The total length of this sea-wall, completed, is 1,202 feet.

In addition to this sea-wall there have been built since July, 1873, for the protection of its concrete foundation where most exposed to injury by storms and currents, 1,005 linear feet of granite apron, and 8 jetties, in which have been placed 1,776 tons of granite grout. This apron has an average width of 10 feet and a height of 2 to 3 feet. It extends all along the 4th, 5th, 6th, 7th, and 8th faces (counting from the east), and for about 55 feet along the 1st face, as well as along the western wing-wall, in order to protect its junction with the shore-crest. The several jetties have a length of 25 to 30 feet, a width of about 6 to 8 feet, and a height of 2 to 3 feet, and they are placed, one at each of the 4th, 5th, 6th, 7th, and 8th angles, one each at the middle of the 1st and 7th faces, and at the easterly wing-wall.

This sea-wall is in excellent condition, and requires but very few repairs; and the riprap apron-work has fully answered the purpose for which it was intended.

2.—SEA-WALL FOR THE PROTECTION AND PRESERVATION OF GREAT BREWSTER ISLAND.

This sea-wall is 2,800 feet in length, and was built for the protection and preservation of the north and south heads of the island. It was commenced in 1849 and was completed in 1854 for a length of 1,360 feet. Its extension was commenced in 1864 and completed in June, 1870.

3.—SEA-WALLS FOR THE PROTECTION AND PRESERVATION OF LOVELL'S ISLAND.

Two sea-walls have been built by the United States Government on this island; one in 1843 for the protection of its north head for a length of 803 feet, and the other in 1868–'69 for the protection of its southeast bluff for a length of about 800 feet.

For the protection of the shore-line south of the north head-wall, an apron-work of large rubble-stone was built in 1873 for a length of 620 feet, with 5 jetties projecting from it, in which 1,095 tons of stone were used; and for the protection of the shore-line next to the southern end of the southeastern sea-wall a rubble-stone apron 110 feet in length was also built in 1873, in which 139 tons of stone were used. A recent inspection of these aprons shows that they have fully answered the purpose for which they were intended.

The sea-wall on the southeast bluff has been much damaged during the past two years by the easterly gales to which it is exposed. It was built in 4 courses, of 2 feet each, on a concrete foundation and with concrete backing, and its back filling of earth was covered with a *cobble-stone* paving. It has, however, become so much broken up and scattered, for a length of about 550 feet of its southern portion, that steps have been taken, with the approval of the department, to reconstruct that portion of the wall and add two more courses of 2 feet each to it and to otherwise increase its strength, as well as to spread an apron of rubble-stone in front of it for the protection of its foundation and of the shore, which has been much abraded of late. The sum of $15,000 has been appropriated for this work, it being the amount estimated for its completion. In response to an advertisement inviting proposals for all the stone required for the work, 17 bids were received and opened on the 31st of May last, an abstract of which is hereto attached. Contracts have been made with the lowest responsible bidders for the same, as follows, viz:

With Mr. Isaac A. Sylvester, of Quincy, Mass., for furnishing and delivering at Lovell's Island—

Five thousand seven hundred cubic feet, more or less, of dimension cut granite, at 39 cents per cubic foot, and 500 tons, more or less, of split granite, for paving, at $1.80 per ton of 2,240 pounds.

Also with the Cape Ann Granite Company, of Gloucester, Mass., for—

One thousand one hundred tons, more or less, of rubble-stone, at 59 cents per ton of 2,240 pounds.

All this stone is to be furnished and delivered before the close of the present working season.

A landing has been built on the south side of Lovell's Island for the purpose of receiving the stone from the contractors, and a railway about 1,000 feet in length has been nearly completed leading from the landing to the sea-wall. It is expected that the reconstruction of the sea-wall will be nearly, if not quite, completed during the present working season.

4.—SEA-WALL FOR THE PROTECTION AND PRESERVATION OF GALLOP'S ISLAND.

This sea-wall is 1,785½ feet in length. Work upon it was commenced in 1868, under a contract with Mr. James Andrews, of Biddeford, Me., and was carried on under that contract until the end of April, 1871, after which it was continued with hired labor until its completion, in the latter part of September, 1871.

The violent storms and currents to which this sea-wall is exposed had laid bare its concrete foundation to such a degree as to render necessary for its protection and preservation a rubble-stone apron for nearly its whole extent, with the addition of jetties in the most exposed places. This apron work was commenced in August, 1873, and was completed in May, 1874. It extends along the sea-wall for a length of 1,665 feet, being on its most exposed faces 10 feet in width. Nine jetties have been built at and near the angles of the wall, 4 of which are of split granite, bedded in part in concrete laid in trenches and surrounded with a concrete apron, each jetty being 18 feet in length and 5 feet in width. The quantity of stone used in this apron and the jetties was about 1,450 tons. A recent inspection of this work shows that it is in good condition, and that the riprap apron work and jetties have fully answered the purpose intended.

5.—SEA-WALL FOR THE PROTECTION AND PRESERVATION OF THE NORTH HEAD OF LONG ISLAND.

Work was commenced upon this sea-wall in August, 1870, and was completed in July, 1874. It has been built, for the most part, under four separate contracts with Mr. James Andrews, of Biddeford, Me., made, respectively, May 24, 1870, July 26, 1871, August 23, 1872, and May 8, 1873. The length of this sea-wall is 2,081¾ feet.

In addition to the sea-wall, there has been built for the protection and preservation of its concrete foundation, where most exposed to injury by storms and currents, a rubble-stone apron for a length of 975 feet in front of the wall, together with 10 stone jetties. This apron averages from 8 to 10 feet in width and from 2 to 3 feet in height. The jetties are triangular in shape and project from 12 to 20 feet beyond the apron; about 900 tons of rubble-stone was used for this work, together with a large quantity of bowlders and cobble-stone found in its immediate vicinity. This apron work was commenced in April, 1874, and completed early in August, 1874.

A recent inspection of this sea-wall shows that it is in good condition, and that the riprap apron work and jetties have fully answered the purpose intended.

6.—SEA-WALLS FOR THE PROTECTION AND PRESERVATION OF DEER ISLAND.

Under appropriations made by Congress in 1825 to 1832, three sea-walls, aggregating 3,000 feet in length, were built for protecting the three prominent heads of this island; that at the North Head being 1,740 feet long and 19½ feet high above its foundation and 14 feet above ordinary high-water; that at the Middle Head, 840 feet long, 17½ feet high above its foundation, and 12 feet above mean high-water; and that at the South Head, 420 feet long, 14½ feet high above its foundation, and 12 feet above mean high-water. These walls were built of regularly split quarried stone with a partial dressing only, and laid dry as headers, the only backing being the clay and gravel in rear, which, silting out through the open joints, left, in course of time, large cavities at several places in rear of the walls, resulting in much damage to the walls, with a probability of their entire destruction. To repair the damage already done, and to prevent its recurrence for the future, the rebuilding of the wall on the North Head was commenced in 1864 by Col. J. D. Graham, Corps of Engineers, by which its several courses, except the lowest, were

laid in mortar and backed with concrete, and otherwise much strengthened, for a length of about 300 feet. This rebuilding was continued until the latter part of 1869, with the following result, as reported by Col. H. W. Benham, while in charge of these walls:

The rebuilding of the wall at the North Head, which was commenced in 1864, was continued until its completion in August, 1869, up to which time 1,740 linear feet of wall was taken up, relaid, and completed in rear. Two split-stone jetties, 25 to 28 feet long, were placed, one at about the middle of the main face of the North Head and the other in a similar position at the Middle Head wall.

The rebuilding of the wall at the Middle Head was commenced in 1866, and completed in 1867 for an extent of 540 feet; all that then appeared to be necessary.

The wall at the South Head was completely rebuilt in a substantial manner, comprising about 420 running feet, in the years 1867 and 1868.

In his report for the fiscal year ending June 30, 1872, Colonel Benham states that the 3 sea-walls pertaining to these bluffs of Deer Island were "in essentially a good condition, especially in the parts that had been rebuilt; that a few defects are found by the falling or drawing out of the foundation-stones, even, in some cases, of the parts rebuilt, from their not having been taken up to the lowest foundation-course, and from the great force of the current or waves along these foundations."

In 1876 and 1877 some repairs were made on the wall at the North Head, and an inspection recently made shows that no additional repairs are needed for the present.

7.—STRAIGHTENING, WIDENING, AND DEEPENING THE MAIN SHIP-CHANNEL AT THE WEST END OF GREAT BREWSTER SPIT.

This work consisted in the removal by dredging of the southern portion of this spit, so as to obtain a depth of 23 feet at mean low-water for a width of not less than 600 feet, with proper slopes up to the 18-foot curve. A survey of this locality, made in August, 1872, showed that the extreme westerly end of the spit had so far advanced into the channel that the low-water line was 120 feet farther out than it was in 1860, and the 18-foot curve was 168 feet from that of 1860.

Under the appropriation made by act of June 23, 1874, for the improvement of this harbor, a contract was made September 3, 1873, with the New England Dredging Company, of Boston, Mass., the lowest responsible bidders for completing this work. Work was commenced under this contract on the 13th of October, and continued until the 29th of October, 1874, when it was suspended for the winter. It was resumed on the 11th of May, 1875, the earliest date practicable, and was continued up to the middle of August, 1875, when all the dredging called for under this contract was completed, resulting in 29,226 cubic yards. Under the same contract with the New England Dredging Company 95½ cubic yards of sunken ledge (laid bare by dredging) were removed to the depth of 23 feet at mean low-water. This work was commenced in June, 1876, and completed in November, 1876.

8.—STRAIGHTENING, WIDENING, AND DEEPENING THE MAIN SHIP-CHANNEL AT THE SOUTHEAST AND SOUTHWEST POINTS OF LOVELL'S ISLAND.

This work consisted of the removal by dredging of the southeast and southwest points of this island, so as to give in "The Narrows" a chan-

nel 600 feet in width for a depth of 23 feet at mean low-water, with proper slopes up to the 18-feet curves. Work was commenced on the southwest point in 1867, under a contract made with Mr. A. Boschké, of Boston, Mass., and was continued during that and the two following seasons, until suspended for want of funds. During this period 207,103 cubic yards of dredging was done by him. A resurvey of this channel made in 1872 showed that it had not changed to any considerable extent at its southwest point since the close of the dredging operation in 1869; that the 18-feet curve was very nearly the same as then, and that the shore above low-water line had acquired a more natural slope of 8 feet horizontal to 1 foot rise by the receding inland of the high-water line, but that the flats of the southeast point of this island had advanced so much toward the main channel as to materially impede and endanger navigation.

Under the appropriation made by act of June 23, 1874, for the improvement of Boston Harbor, a contract was made, September 8, 1874, with Messrs. Boynton Brothers, of Boston, Mass., the lowest responsible bidders, for doing the work projected for the improvement at the southeast point of this island, by 30,000 cubic yards, more or less, of dredging, at 38 cents per cubic yard, as measured in the scows. Work under this contract was commenced on the 7th of October and continued until the 17th of December, 1874, when it was suspended for the winter. It was resumed on the 11th of May, 1875, the earliest date practicable, and was completed September 22, 1875, 31,058 cubic yards having been dredged under this contract.

For completing the projected improvement at and near the southwest point of Lovell's Island, which was suspended in 1869, about 30,000 cubic yards of dredging was required, for which a contract was made, June 2, 1877, with the New England Dredging Company, of Boston, Mass., the lowest of 8 bidders, at 24 cents per cubic yard, as measured in the scows. This work was commenced on the 19th of June, and was satisfactorily completed on the 27th of September, 1877, by 29,133½ cubic yards of dredging.

9.—STRAIGHTENING, WIDENING, AND DEEPENING THE MAIN SHIP-CHANNEL AT THE UPPER MIDDLE BAR.

The work projected for the improvement of this bar consists in opening through it a channel of 600 feet in width, to a depth of 23 feet at mean low-water, through a total distance of about 4,400 feet, the principal difficulties being in a space about 2,200 feet in length, in which the depth to be increased varied from 1 to 7 feet. Under a contract made September 24, 1870, with Emory R. Seward, Albany, N. Y., dredging was carried on at this place until the 1st of June, 1871, at which time 26,120 cubic yards had been excavated under that contract, by which one cut, about 1,800 feet in length, was partially opened to a width of 40 feet, and to a depth varying from 20 to 23 feet at mean low-water.

Under the appropriation made by act of March 3, 1871, a new contract was made, July 29, 1871, with Mr. R. G. Packard, of Brooklyn, N. Y., which was completed June 29, 1872, by 20,305 cubic yards of dredging, making to that date an aggregate of 46,425 cubic yards of dredging. By this work, one cut, about 1,800 feet in length, was opened to a width of 40 feet, to a full depth of 23 feet at mean low-water, and a second cut of the same width and depth, for a length of 1,040 feet, including the removal of a very large bowlder discovered in 1872 in the main ship-channel, with but 16½ feet of water upon it at mean low-water.

Under the appropriation of March 3, 1873, a contract was made, March 5, 1874, with the Atlantic Dredging Company, of Brooklyn, N. Y., for 75,000 cubic yards, more or less, of dredging, at 64 cents per cubic yard, as measured in the scows, and at $35 per cubic yard for excavation of ledge and of bowlders exceeding 6 tons in weight. Operations were commenced in April, 1874, and were continued up to the 14th of December of that year, when they were suspended for the winter.

On the 26th of May, 1875, they were resumed, and continued up to the 17th of December of that year. They were again resumed on the 3d of May, 1876, and were continued up to the 11th of July, 1876, at which time 90,860 cubic yards had been dredged under and in completion of this contract.

Under the appropriation made by act of June 23, 1874, for continuing the improvement of this harbor, a contract was made, September 1, 1874, with the Harbor Improvement Company, of Boston, Mass., for 42,000 cubic yards of additional dredging on the bar, at 85 cents per cubic yard, as measured in the scows. Dredging was commenced under this contract on the 3d of October, and continued until the 14th of December, when it was suspended for the winter. It was resumed on the 8th of May, 1875, and continued up to the 17th of December, 1875, at which time 42,843½ cubic yards had been dredged under this contract. There then remained to be done, for the completion of this contract, the excavation of 37 cubic yards of ledge, which was completed on the 26th of August, 1876.

Under the appropriation made for this harbor by act of March 3, 1875, a contract was made, May 19, 1875, with Messrs. Curtis, Fobes & Company, of Portland, Me., for 90,000 cubic yards, more or less, of additional dredging on this bar and the shoals below it, at 75 cents per cubic yard, as measured in the scows, including bowlders not exceeding 6 tons in weight. Operations were commenced under this contract May 9, 1876, and were completed on the 16th of November, 1876, resulting in 88,150 cubic yards of dredging.

The total quantity of dredging, therefore, that has been done to date, under the several contracts named, amounts to 268,278½ cubic yards, whereby a channel has been opened for a width of 600 feet, and a depth of 23 feet at mean low-water, through the whole of the Upper Middle Bar, in length about 4,400 feet.

During the dredging operations of 1876 at the Upper Middle Bar, a sunken ledge was laid bare covering an area of 227 square yards which was shoal from 0 to 3 feet, requiring the breaking up and removal of 81½ cubic yards of ledge above the 23-feet plane. On the 4th of June, 1877, a contract was made with Mr. George W. Townsend, of Boston, Mass., the lowest of two bidders, for the removal of this ledge to the required grade, at $65 per cubic yard, measured in its bed. He commenced this work on the 8th of April last, and up to the close of the fiscal year had broken up and removed 50 cubic yards, leaving 31½ cubic yards of it yet to be removed, which will probably be completed by the end of July, 1878.

10.—REMOVAL OF NASH'S ROCK (SHOAL).

Nash's Rock, so called, is a shoal lying in the outer entrance to Boston Harbor, about one-third of the way over from Brewster Spit to Point Allerton. This shoal was surveyed in September and October, 1873, and a special report thereon, accompanied by drawings, was submitted to the department on the 24th of March, 1874.

From information acquired by this survey, it was seen that the only portion of this shoal which it would be advisable and practicable to improve, was that having less than 21 feet of water over it at mean low-water, which portion had an area of 637½ superficial yards, and would require, in order to obtain a depth of 21 feet, the excavation and removal of about 500 cubic yards of bowlders, shingle, &c., at an estimated cost of $10,000; whereas to remove the whole shoal to a depth of 23 feet below the plane of mean low-water would require the excavation of over 16,000 cubic yards of similar material over an area of 9.1 acres, the cost of which would be greatly disproportionate to the benefit that would result therefrom.

Under the appropriation made by the act of March 3, 1875, for the improvement of this harbor, a contract was made, May 19, 1875, with Messrs. Curtis, Fobes & Company, of Portland, Me., for removing about one-half of this shoal to the projected depth of 21 feet at mean low-water, which was completed by them in September, 1876.

For completing the removal of this shoal down to the projected grade, a submarine party, with a vessel and crew and all the necessary machinery and explosives, was hired at $50 per day. The party commenced work on the 4th of September, and continued until the 8th of November last, when, owing to the windy weather and strong currents, operations were suspended for the season. During this period, 320 tons of large bowlders and ledge were removed, leaving only about 40 tons to be removed for the completion of the work. This work will be resumed when the weather becomes most favorable for it, and will probably be completed before the end of August. By the work thus far done, this shoal has been so far improved that on its shoalest places there is now a depth of 18½ feet at mean low-water, being an increase of over 3 feet.

11.—REMOVAL OF KELLY'S ROCK AND THE LEDGES NEAR IT.

This rock lies in the main ship-channel, distant about 700 yards, in a direction southeast by south of Bug light (at the Narrows) and in the line of entrance buoy No. 1 and Bug light. In 1869 operations were commenced for removing this rock to a depth of 23 feet below the plane of mean low-water, and were continued up to the end of December, 1870. These operations were continued in June and July, 1873. An accurate survey afterwards made of this rock showed that there still remained an area of about 320 superficial yards of it, which had less than the projected depth on the shoalest parts, on which there were but 21.2 feet of water at mean low-water, and that in order to obtain a full depth of 23 feet would require the removal of not less than 80 cubic yards of the rock.

Under the appropriation made by act of March 3, 1875, for this harbor, a contract was made, May 14, 1875, with Mr. George W. Townsend, of Boston, Mass., for completing the removal of this rock, at $60 per cubic yard. He commenced operations under this contract in the latter part of May, 1875, and completed them on September 30, 1875.

During the removal of this rock in 1875, new ledges were discovered in its vicinity, above and below, having on the shoalest parts a depth of but 20 to 21 feet at mean low-water. These ledges cover an area of about 543 square yards in the 23-foot plane below mean low-water, and 189 cubic yards will have to be removed above that plane.

During the past year an additional area of 310 square yards of ledge has been discovered below Kelly's Rock, having but 17.4 feet of water on its shoalest part at mean low-water, and requiring the breaking up

and removal of about 165 cubic yards of ledge for reducing it to the required grade of 23 feet at mean low-water.

A contract was made June 4, 1877, with Mr. George W. Townsend, of Boston, Mass., the lowest of two bidders, for the removal of the ledges discovered in 1875, at $50 per cubic yard, measured in its bed, above the 23-foot plane. He commenced work under this contract on the 15th of June, 1877, first upon the ledges above (to the westward of) Kelly's Rock, which he completed on the 18th of August, by the breaking up and removal of 26.42 cubic yards above the 23-feet plane. He then commenced work upon one of the spurs of ledge below Kelly's Rock, which he continued up to the latter part of December; but owing to the very unfavorable weather during the greater part of that period, his progress was much less satisfactory than had been hoped for, in having broken up and removed but 50 cubic yards of that ledge, the total quantity accomplished during the season being 76.42 cubic yards. On the completion of the submarine work at the Upper Middle, about the 1st of August, the contractor will resume work upon the ledge below Kelly's Rock, which he will endeavor to complete by the end of the present season, should the weather be as favorable as in most of the past seasons.

12.—REMOVAL OF TOWER ROCK.

This rock was situated in the main ship-channel at "The Narrows," about 100 cubic yards to the southwest of Great Brewster Spit light. It was blasted out and removed in 1867 to the projected depth of 23 feet at mean low water.

13.—REMOVAL OF CORWIN ROCK.

This rock was situated in the main ship-channel at "The Narrows," about 200 yards to the southwest of Great Brewster Spit light. It was blasted out and removed in the years 1868 and 1869 to the projected depth of 23 feet at mean low-water.

14.—REMOVAL OF SUNKEN LEDGE BETWEEN GEORGE'S ISLAND AND GREAT BREWSTER SPIT.

This ledge was discovered in 1872, in a resurvey of "The Narrows." It was situated near the middle of the main ship-channel, directly in the track of all large vessels, and particularly of the European steamers, and was distant 317 yards in a direction west by south from Bug light. It had but 18.9 feet of water upon it at mean low-water, and was therefore a dangerous obstacle to navigation.

Under the appropriation of June 23, 1874, a contract was made, August 31, 1874, with Mr. William H. Lloyd, of Boston, Mass., for the removal of this ledge to a depth of 23 feet at mean low-water—altogether 16⅛ cubic yards—for the sum of $400, which he completed early in September, 1875.

15.—REMOVAL OF BARREL ROCK, IN BROAD SOUND.

This was a bowlder lying about 1 mile a little north of west from Green Island, and near the sailing line of the Portland and other Maine steamers. It had only 4 feet of water over it at low tide, and in thick weather was a dangerous obstacle to navigation. It was removed in 1869.

16.—REMOVAL OF STATE AND PALMYRA ROCKS.

A special survey was made of these rocks, of which a report an drawings were transmitted to the department on the 25th of May, 187 By this survey it was ascertained that State Rock and Palmyra Roc of the position and character of which but little previously had be known, are situated very near each other, and most probably are ou croppings of the same ledge, forming spurs on the southern side of t Lower Middle Bar, about one-half a mile east of Castle Island.

To effect the improvement proposed required altogether the remov of about 62 cubic yards of rock, for which a contract was made, Augu 31, 1874, with Mr. William H. Lloyd, of Boston, who was the lowe of two bidders, at $1,500 for the job, Mr. Lloyd commenced work up the removal of the rocks in September, 1874, and continued up to t middle of November, when, on account of the weather he was obliged suspend for the winter. He resumed work about the 1st of June, 18 and completed their removal on the 15th of that month.

17.—REMOVAL OF THE WRECK OF THE SCHOONER DELOS.

This was an old vessel of about 100 tons burden, deeply loaded wi gravel in her hold and on deck, destined for the engineer work at F Warren, and was sunk in the gale of November 12, 1872, in Nantask Roads, about 100 yards from Fort Warren wharf, in about 22 feet water at low water. When examined in December, 1872, she w stripped of her masts and rigging, and was much shattered, and h about 14 feet of water over her at mean low-water. The breaking up a removal of this wreck was commenced on May 29, 1873, and was co pleted in the early part of June.

From the foregoing statement it is seen that the following work h been done during the past fiscal year, viz:

1. The channel at the southwest point of Lovell's Island was increas to a width of not less than 600 feet for a depth of 23 feet at mean lo water.

2. The ledge above Kelly's Rock (26.42 cubic yards) has been entir removed to a depth of 23 feet at mean low-water.

3. Fifty cubic yards of the ledge below Kelly's Rock has been brok up and removed to a depth of 23 feet at mean low-water.

4. Fifty cubic yards of the ledge has been broken up and removed the projected depth from the Upper Middle Channel, leaving 31½ cu yards yet to be removed.

5. About 320 tons of large bowlders and ledge have been remov from Nash's Rock (Shoal), leaving about 40 tons yet to be removed.

6. Contracts have been made and work commenced for furnishing a delivering the stone required for the reconstruction of the sea-wall the southeast bluff of Lovell's Island, and a landing and railroad tra nearly completed for receiving and moving the stone, with a probabil of the completion of the wall by the end of the present working seas

7. A survey made of Anchorage Shoal and the mouth of Mys River, in the upper harbor, of which reports, drawings, and estimat for their improvement have been submitted to the department.

By the dredging of the past season at and near the southwest poi of Lovell's Island, together with that completed in 1875 at the sou east point of Lovell's Island, and that in 1876 at the west end of Gr Brewster Spit and at the Upper Middle Bar, all the *dredging* hithe projected for the improvement of this harbor from its entrance up

Anchorage Shoal has been completed, giving a channel not less than 600 feet in width and 23 feet in depth at mean low-water, (or about 32½ feet at ordinary high water), except at the Lower Middle, where it is only 400 feet wide in its narrowest part, and except where obstructed by the sunken ledges recently discovered near Kelly's Rock and in the Upper Middle Channel, which have as yet been but partially removed.

The work that now remains to be done for completing all the improvements for which projects and estimates have hitherto been made, consists of the following, viz:

a. Completing the breaking up and removing 31½ cubic yards of ledge in the Upper Middle Channel, now contracted for at $65 per cubic yard..	$2,047 50
b. Completing the breaking up and removal of 131½ cubic yards of sunken ledge below Kelly's Rock, now contracted for at $50 per cubic yard....	6,575 00
c. Completing the improvement of Nash's Rock Shoal, say.....	1,000 00
d. Reconstructing sea-wall on southeast bluff of Lovell's Island, now contracted for in part.....	14,500 00
e. Removal of Man-of-War Shoal, by dredging to a depth of 23 feet at mean low water, at an estimated cost (for 65,000 cubic yards at 50 cents) of.....	32,500 00
f. Breaking up and removing 145.78 cubic yards of ledge below Kelly's Rock, at $50 per cubic yard (not contracted for).....	7,289 00
g. Adding for contingencies, say.....	6,789 74
Total.....	70,701 24

which is the balance now available of the appropriations thus far made exclusively for the above works.

The following additional works, for which estimates are submitted, require for their completion appropriations for the full amount stated, viz:

h. The projected improvement of Anchorage Shoal (next above the Upper Middle), now the only obstacle to the passage of ocean steamers and other deep-draught vessels from the ocean up to the upper harbor of Boston in all stages of the tide.

A survey of this shoal made during the past year shows that it has a very irregular shape, and extends into the main channel chiefly from the East Boston and Bird Island flats, having in its shoalest part but 15½ feet of water at mean low-water, or about 25 feet at ordinary high-water, and that the greatest depth that can be carried over the southern part is 22 feet at mean low-water for a width of about 300 feet, or 21 feet for a width of about 500 feet. To open this channel to a depth of 23 feet at mean low-water (the same depth of all the improvements in the channel below) for an average width of 1,100 feet, which width is necessary in this central position of the harbor, to enable vessels, on entering or leaving this channel, to have free communication with all parts of the harbor, would require—

One hundred and thirty-five thousand cubic yards of dredging, over an area of about 130,000 square yards of the shoal, the estimated cost of which, at 60 cents per cubic yard, is.....	$81,000 00
Adding for engineering expenses and other contingencies, say.....	9,000 00
	90,000 00

i. Increasing to a width of 600 feet the main ship-channel at the Lower Middle, by the removal of spurs projecting from its southern side, requiring 5,000 cubic yards of dredging, the estimated cost of which, including contingencies, is.....	5,000 00

During the past year an examination has also been made of this harbor at and near the mouth of Mystic River, with a view to its improvement to an extent commensurate with the present great and prospectively increasing demands of the commerce of that portion of the harbor. A

special report on this subject, accompanied with a drawing and estim
was submitted to the department on the 3d of May, 1878, by w
it will be seen that very extensive improvements have been made in
years in this part of the upper harbor of Boston, owing to the sup
facilities which it affords to ocean steamers and other vessels of the lar
class. On the western side of the river, between the United States n
yard and Chelsea Bridge, extensive piers and docks have been built,
others are now in progress, with berths for ocean steamers dredged
depth of 25 feet at mean low-water, together with a channel of the
depth and 100 feet in width leading from the berths outward to
water. The East Boston side of this harbor, opposite the navy-ya
also lined with wharves, for a distance of about one mile, and offers
advantages to shipping, securely sheltered as it is from all storms.
river has a depth of 23 feet and more at mean low-water, except w
obstructed by the shoal opposite the wharves of the navy-yard,
length of about 500 yards, on the shoalest part of which there is not
than 15 feet of water at mean low-water. The commerce of this h
would doubtless be much benefited by removing this obstructio
dredging to a depth of 23 feet at mean low-water, or about 33 fe
ordinary high-water (the same minimum depth that is adopted fo
harbor below), for a width of 300 feet. This would require—

About 125,000 cubic yards of dredging, the estimated cost of which, at 50 cents per cubic yard, is	$62,
Additional for engineering expenses and other contingencies, say	7,
Total	70,

The additional appropriation that will be required for impr
Anchorage Shoal, the Lower Middle, and Mystic River, as estin
above, is, in the aggregate, $165,000.

The several works built and projected for the improvement of this harbor lie
the port of Boston, and in the collection district of Boston and Charlestown, M

The following information in regard to the revenue and commerce o
port of Boston for the year ending December 31, 1877, has been furn
by the United States collector of customs at that port, viz:

Amount of revenue	$13, 037,
Value of imports	47, 720,
Value of exports	43, 563,

	Number.	T
American vessels arrived	690	2
Foreign vessels arrived	1, 506	5
American vessels cleared	617	2
Foreign vessels cleared	1, 377	4

Number of vessels built, 20, with an aggregate tonnage of 10,895.56.

The following-named papers are hereto appended, viz:

1. Abstract of proposals received.
2. Abstract of contracts made.

Money statement.

July 1, 1877, amount available	$41, 291 61	
Amount appropriated by act approved June 18, 1878	55, 000 00	
		$96,
July 1, 1878, amount expended during fiscal year	21, 090 17	
July 1, 1878, outstanding liabilities	4, 500 20	
		25,
July 1, 1878, amount available		70,
Amount (estimated) required for completion of existing project		165,
Amount that can be profitably expended in fiscal year ending June 30, 1880		165,

Abstract of proposals received May 31, 1878, for improvement of Boston Harbor, Massachusetts.

[Stone to be delivered at Lowell's Island in Boston Harbor.]

Number for reference.	Bidders.	Residence.	5,483 cubic feet dimension-cut granite, per cubic foot.	217 cubic feet coping, per cubic foot.	500 tons paving, per ton 2,240 pounds.	1,100 tons granite grout, per ton 2,240 pounds.
1	Isaac A. Sylvester	Quincy, Mass	$0 39	$0 39	$1 80	$0 85
2	C. J. Hall	Mount Desert, Me	37½	40	2 45	1 25
3	Cape Ann Granite Company	Gloucester, Mass	39¾	39¾	2 58	59
4	C. H. Bragdon	Biddeford, Me	38	40	2 80	1 15
5	C. A. Peirce & Co	Rockford, Mass	46	46	1 99	69
6	Derry & Edwards	Boston, Mass	43	50	2 62	70
7	Gooch & Haynes	Biddeford, Me	39	45	3 40	.....
8	Bodwell Granite Company	Rockland, Me	48	51	2 40	1 35
9	Rockport Granite Company	Rockport, Mass	53	53	2 25	90
10	Oliver Jordan	Yarmouth, Me	41	45	3 95	.....
11	Collins Granite Co., East Blue Hill, Me	Philadelphia, Pa	45	55	3 75	2 00
12	Albion S. Hamilton and Simeon Hamilton	Portland, Me	54	65	3 07	1 03
13	Davis Tillson	Rockland, Me	59	62	3 00	1 49
14	Willett Andrews	Biddeford, Me	60	60	3 00	1 50
15	Crabtree & Harvey	Sullivan, Me	59	67	3 50	.....
16	Joseph H. West	Franklin, Me	61	67	3 75	.....
17	James Ginn	Bath, Me	1 50	1 50	2 50	2 50

Abstract of contracts made during the fiscal year ending June 30, 1877, for delivering stone at Lovell's Island, in Boston Harbor, Massachusetts.

Date of contract.	Contractors.	Nature of work.	Price.
June 3, 1878	Isaac A. Sylvester, of Quincy, Mass.	For 5,700 cubic feet, more or less, dimension-cut granite.	39 cents per cubic foot.
		For 500 tons, more or less, split granite.	$1.80 per ton of 2,240 pounds.
June 10, 1878	Cape Ann Granite Company, of Gloucester, Mass.	For 1,100 tons, more or less, granite grout rubble-stone.	59 cents per ton of 2,240 pounds.

A 12.

IMPROVEMENT OF PLYMOUTH HARBOR, MASSACHUSETTS.

The existence of this harbor depends entirely upon the protection and preservation of Long Beach, which is a narrow strip of land that extends 2¾ miles out from the mainland in a northwesterly direction, nearly parallel to the shore of the town of Plymouth, and distant from it about one mile. It affords to the harbor its only shelter from easterly storms. In late years it has been washed away in some places, and much weakened in others, to an extent seriously threatening the ruin of the harbor. For the protection and preservation of this beach various works have been built from time to time, until finally they have proved efficient and successful.

The total amount that has been appropriated by Congress for the preservation and improvement of this harbor, from 1824 up to and including June 18, 1878, is $118,567.

Of this amount there has been allotted to and appropriated for this

harbor, since the resumption of work on rivers and harbors in 1866, sums as follows, viz:

Amount allotted in 1866, from appropriations made July 2, 1864, for harbors on the Atlantic coast	$8,30
Amount allotted under act of July 25, 1868	7,50
Appropriated by act approved July 11, 1870	10,00
Appropriated by act approved March 3, 1871	10,00
Appropriated by act approved June 10, 1872	2,50
Appropriated by act approved March 3, 1873	3,00
Appropriated by act approved June 23, 1874	5,00
Appropriated by act approved March 3, 1875	10,00
Appropriated by act approved June 18, 1878	5,00
Total	61,30

A history and description of the several works built for the protec and preservation of Long Beach will be found in the annual report the fiscal year ending June 30, 1877, from which it is seen that the eral amounts that have been allotted to and appropriated for the provement of Plymouth Harbor since 1866 have been applied to construction of bulkheads, jetties, and groins, and the planting of be grass where most necessary for protecting and strengthening Long B throughout its whole extent of about 2¾ miles.

The bulkheads and jetties have accumulated a large quantity of s forming a ridge throughout its whole extent, and the beach-grass co nearly all this newly formed beach, which is now in efficient condi Repairs, however, are now necessary, as they doubtless will contin be from time to time along this beach, exposed, as it is, to injury by lent storms. Something more should also be done for increasing efficiency of the stone bulkhead at the outer end, and its connec with the beach.

The estimated cost of this work is as follows, viz:

1. 1,000 tons rubble-stone, at $2	$2,0
2. Repairs of bulkhead near inner end of beach (partially burned of late)	2
3. Repairs of bulkhead and jetties	7
Adding for contingencies, say	5
Total	3,5

A survey was made of this harbor in February, 1874, in compli with a resolution of the House of Representatives dated December 1873, "with a view to dredging and improving the same so as to a greater protection and facilities to commerce."

The plan that has been projected for the improvement of this ha is to open a channel by dredging through the sand, mud, and clay, the Middle Ground up to Long Wharf, a distance of about 2,500 the channel to have a width of 100 feet, and a depth of 6 feet at n low-water, or 16 feet at mean high-water; this channel to be exte southward, in front of the wharves above Long Wharf, for a distan about 900 feet to the mouth of Town Brook, so as to form a basin feet in width and 8 feet in depth at mean low-water. The total quan of dredging required for this improvement was estimated at about 11(cubic yards.

Under the appropriation of $10,000, made by act of March 3, 187 improving this channel as above projected, a contract was made Ma 1875, with Mr. Augustus R. Wright, of Geneva, N. Y., the lowest bid at 23 cents per cubic yard, as measured in the scows, for 35,000 c yards, more or less, of dredging, to be applied to the partial excava of the projected channel. Dredging was commenced under this cont on the 19th of April, 1876, and was completed on the 21st of June, 1

resulting in 34,985 cubic yards of dredging, whereby a channel was opened up to the wharves of Plymouth for a width of 50 feet, and to a depth of 6 feet at mean low-water.

To complete this channel and basin will therefore require about—

Seventy-five thousand cubic yards more of dredging, the estimated cost of which, at 30 cents per cubic yard, is		$22,500 00
Adding for contingencies, say		3,000 00
Total		25,500 00
The estimated cost of works and repairs now necessary for the protection and preservation of Long Beach, as above, is, including contingencies	$3,500 00	
For probable repairs to be provided for for the fiscal year ending June 30, 1880	1,000 00	
		4,500 00
		30,000 00
Amount appropriated by act of June 18, 1878		5,000 00
Additional amount required for completing the improvement as projected is		25,000 00

Application has been made to the collector of customs at Plymouth for information as to the revenue and commerce of that port, but no reply has been received.

Money statement.

July 1, 1877, amount available	$93 92	
Amount appropriated by act approved June 18, 1878	5,000 00	
		5,093 92
July 1, 1878, amount expended during fiscal year		5 85
July 1, 1878, amount available		5,088 07
Amount (estimated) required for completion of existing project		25,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		25,000 00

A 13.

IMPROVEMENT OF PROVINCETOWN HARBOR, MASSACHUSETTS.

The following amounts have been allotted to and appropriated for the preservation of this harbor since the resumption of work on rivers and harbors in 1866, viz:

Amount allotted 1866 from appropriation made July 2, 1864, for harbors on the Atlantic coast	$15,000 00
Amount appropriated by act of June 23, 1866	43,068 44
Amount allotted under act of April 10, 1869	9,000 00
Amount appropriated by act of March 3, 1871	6,000 00
Amount appropriated by act of June 10, 1872	5,000 00
Amount appropriated by act of March 3, 1873	6,000 00
Amount appropriated by act of June 23, 1874	6,000 00
Amount appropriated by act of March 3, 1875	5,000 00
Amount appropriated by act of August 14, 1876	4,000 00
Amount appropriated by act of June 18, 1878	1,000 00
Total	100,068 44

Under the appropriation of $4,000 made by the river and harbor act of August 14, 1876, the following work was projected for the further preservation and improvement of this harbor, to wit:

1. Raising and extending the stone bulkhead on the extremity of Long Point, the stone therefor to be furnished by contract; and

2. Repairs of the bulkheads and jetties at Beach Point and Cove Section, and of the dikes at High Head and Abel Hill where necessary, and planting beach-grass on the outer beach; this work to be done by men hired by the day.

Contracts were made with the following parties, who were the lowest bidders, for furnishing the stone required for raising and extending the bulkhead on Long Point, to wit:

1. With Alpheus C. Pierce, of Rockport, Mass., for 1,000 tons, more or less, of large quarry grout, at $1.59 per ton of 2,240 pounds, under contract of May 31, 1877; and

2. With Isaac A. Sylvester, of Quincy, Mass., for 700 tons, more or less, of small rounded boulders, at $1.48 per ton of 2,240 pounds, under contract of June 4, 1877.

Mr. Pierce had furnished and placed upon the work, up to the 1st of July, 1877, under his contract, 558½ tons of large quarry grout, and on the 28th of July he completed his contract on the delivery of an aggregate of $1,114\frac{640}{2240}$ tons.

Mr. Sylvester commenced furnishing small stone under his contract in the latter part of July, and completed the same on the 21st of September, 1877, by the delivery of a total of $745\frac{200}{240}$ tons.

During the month of November last, the outer end of the stone bulkhead on Long Point was repaired and regulated, the work having been done by a vessel and crew hired by the day.

By the end of December last all the repairs were completed, where necessary, upon the works at Beach Point, Cove Section, High Head and elsewhere.

All the works projected for the preservation and improvement of this harbor were thus finally completed, and the funds nearly expended. These works consist of the following, to wit:

1. Bulkheads and jetties of various descriptions have been built from time to time along Beach Point for its preservation and protection, both by the United States Government and by the local authorities.

2. A dike was built in 1868 and 1869 by the State of Massachusetts across the outlet of East Harbor Creek.

3. A dike, 690 feet in length, was built in 1868 and 1869, by the United States Government, across East Harbor Creek at the Wading Place near High Head, about 2 miles above the outlet of the creek.

4. In 1867–'68, about 6,000 linear feet of fence bulkheads and jetties were built for the protection and preservation of the beach at Long Point and Beach Point.

5. A stone bulkhead, about 1,000 feet in length, has been completed for the protection and preservation of the outer end of Long Point, the light-house, and Three-gun Battery.

6. A substantial dike (272 feet in length) was built in 1871–'72 across the head of Lancey's Harbor, near Abel Hill.

7. Beach-grass planted on Beach Point, Long Point, Abel Hill, Cove Section, and Oblique Section, and at the last two places brush has also been laid for their further protection.

8. The projected extension of the several jetties on Beach Point and State Dike has been completed.

9. A bulkhead and six jetties built for the preservation and protection of the beach at Cove Section, near High Head, were encroached upon by the extraordinary gales of November, 1873, and January, 1874. This bulkhead is 607 feet in length, and the jetties have an aggregate length of 126 feet. They consist of a frame-work filled with brush and ballasted with stone, and were completed in December, 1874.

works at Cove Section have accumulated the sand to such an oth in height and width (since covered and strengthened with ass), that it is believed that this weak portion of the beach is ıre against further encroachment by gales.

e above-described works are generally in excellent condition, e fully answered the purpose for which they were designed. l, however, require constant watching and occasional repairs, as they are to injury from the violent storms to which they sed. For this purpose an additional appropriation of $1,000 is nded for the fiscal year ending June 30, 1880.

propriation of $1,000 made for the improvement of this harbor ver and harbor act of June 18, 1878, or so much thereof as may t be necessary, it is proposed to apply to strengthening the bulkhead on Long Point and to such repairs as may be neces- ıe several other works built for the protection and preservation rbor.

rd to the estimates for the work done for the preservation of or, they appear to have generally agreed with the amounts that n appropriated and expended therefor. Much of the work, has been for repairs and extensions not foreseen, but abso- cessary to be made as they occurred, for which no previous could be made.

own, in which the above-described works are situated, is a port of entry collection district of Barnstable, Mass.

owing information in regard to the revenue and commerce of for the year ending December 31, 1877, has been furnished by d States collector of customs at that place, viz:

revenue collected	$2,454 10
ports	1,686 00
ports	14,032 00

ırrivals and departures of vessels, 10,170.

Money statement.

amount available	$3,170 67	
ropriated by act approved June 18, 1878	1,000 00	
		$4,170 67
amount expended during fiscal year		3,063 38
amount available		1,107 29
mated) required for completion of existing project		1,000 00
can be profitably expended in fiscal year ending June 30, 1880.		1,000 00

APPENDIX B.

ANNUAL REPORT OF MAJOR G. K. WARREN, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1878.

ENGINEER OFFICE, UNITED STATES ARMY,
Newport, R. I., August 3, 1878.

GENERAL: I have the honor to submit the annual reports of improvements of rivers and harbors under my charge during the fiscal year ending June 30, 1878.

Very respectfully,

G. K. WARREN,
Major of Engineers and Bvt. Maj. Gen., U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

B 1.

IMPROVEMENT OF HYANNIS HARBOR, MASSACHUSETTS.

Hyannis is situated on the south side of Cape Cod, on Nantucket Sound. Hyannis Harbor is the sheltered area between the breakwater and the shore.

This breakwater is about 1,170 feet long, with a depth of 12 feet at mean low-water between it and the shore. It was begun in 1828 and continued with few interruptions until 1837, $70,931.82 having been expended upon it. In 1853 $5,000 was expended in repairing the east end. Since 1870 $37,000 has been expended in rebuilding the part above water and increasing the width of the part below low-water.

Nothing has been done on the breakwater at this place during the fiscal year.

An appropriation of $3,000 was made by act of Congress approved June 18, 1878, for continuing the improvement. With this amount it is proposed to strengthen the breakwater by putting riprap granite about its base, so as to increase the slope to one on two on the seaward side, and one on one on the shore side.

A history of this work was given in the Annual Report of the Chief of Engineers for 1875, part 2, pp. 266–268.

The amount then estimated as required to complete the work was $10,000. This amount less the amount appropriated this year is needed to give the work the required width of base.

I would call attention to the importance of putting a light-house on the east end of the breakwater instead of the present one on the shore.

Hyannis is in the Barnstable collection district. Barnstable is the nearest port of entry. The amount of revenue collected there during the fiscal year ending June 30, 1878, is not known to this office.

Money statement.

July 1, 1877, amount available	$42 94	
Amount appropriated by act approved June 18, 1878	3,000 00	
		$3,042 94
July 1, 1878, amount expended during fiscal year		42 94
July 1, 1878, amount available		3,000 00
Amount (estimated) required for completion of existing project		7,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880		7,000 00

B 2.

IMPROVEMENT OF WAREHAM HARBOR, MASSACHUSETTS.

This harbor is an estuary joining Buzzard's Bay near its upper or northern end. The part improved by the general government extends from Wareham, where it is crossed by a railway and a highway bridge, neither of which has draws, to Buzzard's Bay, a distance of 2 miles. The improvement of this harbor, which was completed in 1876, was to make a channel 9 feet deep at mean low-water, and from 100 to 300 feet wide in the upper part of the harbor, and 10 feet deep and from 250 to 300 feet wide in the lower part of the harbor. The mean rise of the tide is 4 feet. The depth before the improvement commenced was 7½ feet at mean low-water, in a narrow and crooked channel.

A history of the improvement may be found in Annual Report of the Chief of Engineers for 1877, Part 1, pp. 194–196. The work done under the last two appropriations was at a much less price than estimated, so that we had about $2,000 remaining on hand when the improvement was completed. With this amount it was deemed best to build a "sand-catcher" along Long Beach to arrest the sand carried over it by the waves in storms into the harbor. This work was commenced last season and will be completed in this season.

No further appropriation is needed unless a greater depth is required than when the plan was adopted.

Wareham is a port of delivery. It is in the New Bedford collection district, and New Bedford is the nearest port of entry. The amount of revenue collected there during the fiscal year ending June 30, 1878, was $23,762.33.

Money statement.

July 1, 1877, amount available	$2,057 74
July 1, 1878, amount expended during fiscal year	1,153 38
July 1, 1878, amount available	904 36

B 3.

IMPROVEMENT OF NEW BEDFORD HARBOR, MASSACHUSETTS.

This harbor is an arm of Buzzard's Bay on its north shore, and receives the waters of the Acushnet River. It is the terminus of the New Bedford division of the Boston, Clinton and Fitchburg Railroad, by means of which it has become a large distributing point for anthracite coal.

also large manufacturing establishments, and it has the largest ing fleets of any port on our coast. The population of New nd Fair Haven opposite it is about 25,000.
y was made by authority of Congress in 1874, a report of which in the Annual Report for 1875, Part 2, pp. 283–287. The bmitted was to make a channel 200 feet wide and 15 feet deep ow-water, from the deep water in front of Fair Haven to the t New Bedford across the shoals, where the ruling depth be-. 2½ feet at mean low-water. The mean rise of the tide is 3.7

th of 15 feet was adopted here because that was about all that uld carry over the shoals before reaching Fair Haven.
ount estimated to complete the work was $24,000.
ropriation of $10,000 was made by act approved March 3, 1875. with the lowest bidder, the Atlantic Dredging Company, for per cubic yard, made a channel 15 feet deep and 105 feet wide. f it is straight from deep water at Fair Haven to Commercial ew Bedford, the first location being a little changed to secure ges for sheering.
r appropriation of $10,000 was made by act approved August ut the work was not authorized until the following April. A as made with Mr. W. H. Molthrop (Morris F. Brainard doing , the lowest bidder, at 10¼ cents per cubic yard. The low ed delays in executing the contract, and the time had to be to June 30, 1877.
price not only enabled us to complete the channel to the width ed, but to increase it to a width of 300 feet, and to extend it 00 feet farther up the harbor along the harbor-line in front of es occupied by the whalers, and to the channel leading to the ve the bridge.
ding Railroad Company have done considerable dredging from channel to their wharves.
terial dredged by the government was first dumped in Clarke's rward east of Egg Islands, both places entirely out of the harbor. ropriation was asked for the fiscal year ending June 30, 1879. sked for the succeeding fiscal year, as the improvement, as far ized, is completed.
erations in the last fiscal year were superintended by Mr. H. A. ssistant engineer.

Money statement.

, amount available	$9,654 60
, amount expended during fiscal year	8,852 78
, amount available	801 82

B 4.

ROVEMENT OF FALL RIVER HARBOR, MASSACHUSETTS.

ver, the largest cotton-manufacturing town in the United situated on Mount Hope Bay, an arm of Narragansett Bay. Harbor is that part of the bay in front of the town. The oved by the general government lies between the Rodman

wharf and the wharf used by the steamers running to Providence, a distance of about 1,500 feet. The improvement sought was a channel 12 feet deep and 100 feet wide at the narrowest part, at mean low water, where the depth was from 6 to 12 feet. The mean rise of tide is 4.7 feet. The harbor was surveyed in September, 1873, and a report with plan and estimates submitted by me December 31, 1873, and printed in Annual Report of the Chief of Engineers for 1874, Part 2, pp. 284–286.

The amount estimated as necessary to complete the improvement as designed was $45,000.

By act of Congress approved June 23, 1874, $10,000 was appropriated for this work. With this amount the bowlders lying on the surface were removed by contract, at the rate of $3.50 per ton. The amount removed under this contract was 1,047¾ tons of bowlders, and 364 tons of gravel and small bowlders. An additional appropriation of $10,000 was made by act of Congress approved March 3, 1875. This, with the unexpended funds of the previous appropriation, was expended in removing, by contract, 21,222.19 cubic yards of material, including bowlders of 2 cubic yards and less, at 48 cents per cubic yard, and 136.53 cubic yards of bowlders over that size.

By act of Congress approved August 14, 1876, $10,000 was appropriated for this work. This was expended, by contract, during the present fiscal year, in removing 12,857½ cubic yards of material, including bowlders of 1 cubic yard, at 55 cents per cubic yard, and 176.34 cubic yards of bowlders over 1 cubic yard in size, at $8.40 per yard.

The low prices at which the dredging was done enabled us to make a channel 160 feet wide and 12 feet deep, with an additional width of 100 feet 11 feet deep at mean low-water, with the $30,000 appropriated. The original estimate was $45,000 for a channel 100 feet wide. The cost of dredging was estimated at $1 per cubic yard; it was done at 48 and 55 cents.

The improvement is now completed with a channel of the depth sought and an increased width.

This improvement is in the Fall River collection district, and Fall River is the port of entry. The amount of revenue collected there during the fiscal year ending June 30, 1878, is $18,970.05.

The work during the past year has been under the superintendence of Mr. H. A. Bentley, assistant engineer. In November and December, 1875, while the improvement was being prosecuted, tidal observations for a lunation were made in order to establish a mean low-water plane, and determine the rise and fall of tide. The following is a table of these observations:

Date.	High-water.	Low-water.	Date.	High-water.	Low-water.
1875.	*Feet.*	*Feet.*	1875.	*Feet.*	*Feet.*
November 9	6.3	2.4	November 24	5.9	2.7
10	6.7	2.0	26	6.9	2.4
11	7.0	1.8	27	6.8	2.0
12	7.1	1.4	29	7.0	1.9
13	7.4	1.0	30	6.2	1.7
15	7.5	1.4	December 1	6.7	2.0
16	7.2	1.0	2	6.4	2.3
17	6.8	1.3	3	6.2	2.7
18	6.1	1.5	4	6.5	2.2
20	5.6	2.1	6	6.4	2.4
22	6.4	2.0	7	6.6	2.1
23	6.6	2.5			

Mean rise and fall 4.7 feet. Mean low-water is referred to a bench-mark, which is the top of the foundation-stone at the northwest corner of Massasoit Flour Mill. It is 9 feet 7 inches above mean low-water. An arrow cut in the stone points to the mark.

Money statement.

ıly 1, 1877, amount available	$10,256 47
ıly 1, 1878, amount expended during fiscal year	10,256 47

B 5.

IMPROVEMENT OF TAUNTON RIVER, MASSACHUSETTS.

This estuary, or so much of it as has been improved by the general vernment, extends from Weir to Dighton, a distance of about 6 miles, ıere it joins or widens out into a bay. The name Taunton River is, wever, sometimes applied to this estuary as far down as Fall River, miles below. At Weir it is spanned by a draw-bridge with two open-gs of about 40 feet each. At low-water the river is in many places less ın 100 feet in width, and before dredging there was not more than 1 ɔt depth in the shoalest places. The mean rise and fall of tide at ghton is 5.28 feet; at Weir since the improvement, 3.41 feet; before y improvements were made, it was probably not greater than 2½ feet the latter place; but the exact range then is not known.

The improvement sought at first was to get small sailing-vessels up to 'eir. In 1852 a survey was made by Lieutenant Rosecrans, and in ecember, 1853, an estimate for a channel 60 feet wide and 4 feet deep mean low-water was submitted by Capt. George Dutton, United ates Engineers. In March, 1870, Capt. J. A. Smith, United States ngineers, in a report upon this improvement, estimated for a channel the same dimensions as that of Captain Dutton. An appropriation $10,000 was made by Congress July 11, 1870, and another appropria-on of $10,000 by act approved March 3, 1871. These amounts were pended in dredging a channel through the "Needles." On the com-letion of this dredging General Thom, United States Engineers, had a rvey made, and from this survey made an estimate of the amount of aterial to be removed to secure a channel 9 feet deep at mean high-ater up to Weir. The amount estimated as necessary to be removed as 31,000 cubic yards, or about twice as much as for the improvement Captain Dutton in 1853 and Captain Smith in 1870.

It will be observed that the depth sought in General Thom's plan was feet at high-water, while that estimated for by Captains Dutton and mith was 4 feet at mean low-water. This with the mean rise of about ½ feet at Weir would give a draught of about 7½ feet at mean high-ater.

At the time the first estimates were made only small sailing-vessels scended the river at high-water, and the smallest of these only went bove the obstructions at the "Needles," the others unloading below. As oon as the channel was dredged through the "Needles," larger vessels ere employed and tugs used to tow them up and down the river.

This work was transferred to my charge July 1, 1872. The appropri-tion of $10,000 made by act approved June 10, 1872, was expended by ne in dredging a channel through Burt's Shoal and Pond's Rocks Shoal, 0 feet wide and 4½ to 5 feet deep at mean low-water, in accordance with he plan submitted by General Thom. Surveys were made during the eason of the shoals not before surveyed. A set of observations were nade to establish the low and high water planes from Dighton to Weir. The appropriations of $10,000 made by act approved March 3, 1873, and

$10,000 by act approved June 23, 1874, were expended in dredging and removing bowlders. In April, 1873, a survey was made of the channels dredged, of the shoal above Berkley Bridge, of the obstructions at the "Nook," at Peter's Point, and of Cobb's Shoal at Dighton. No detailed examinations had been made at these points, and only approximate estimates for the removal of the obstructions.

As before stated, vessels are almost invariably towed up and down this river. The tugs with their vessels and scows start from Dighton on the flood-tide as soon as they can cross the rocks and shoals in that part of the river, in order to reach Weir by or before high-water, and that a new tow can be formed to take down the river on the first of the ebb.

If any delay occurs in taking the tow up so that they cannot leave Weir until after ebb has commenced, they will not reach the obstructions at and near Dighton until the tide has fallen 2 feet. Here, then, under these circumstances, we would not have secured a 9-foot draught for vessels by making 9 feet depth at mean high-water. To do this it was determined to make in the work below the "Needles" 10 feet depth at mean high-water.

With the $10,000 appropriated by act approved March 3, 1875, a channel 10 feet deep at mean high-water was dredged through Cobb's Shoal at Dighton, and of the same depth at Wikamount, and bowlders removed from the "Nook," and the point of the ledge extending into the channel-way at Peter's Point. This completed the improvement designed to allow vessels of 9-feet draught to ascend to Weir at time of mean high-water, except the shoal at Berkley Bridge and some bowlders scattered along the channel and in sharp bends.

To do this it was estimated $5,000 would be required. With 9 feet secured in this river, except on the sand shoal at Berkley Bridge, which lacks but a few inches of the required depth, vessels and barges have been employed drawing nearly or quite this depth, and as the tugs start with them at Dighton before high-water they strike at Berkley Bridge Shoal, and often at new shoals and bowlders above, which probably have 9 feet at mean high-water, but not at any lower stage of the tide.

The barges used here are very long, and frequently in making the short turns strike both banks of the channel.

The bowlders are dangerous obstructions, and with the $2,000 appropriated by act of Congress approved June 18, 1878, it is proposed to remove them as far as the funds will pay for. The removal of Berkley Shoal to 10 feet depth at mean high-water would allow vessels to go farther up before striking, but it is deemed best to leave this as a limiting depth and use the available funds in removing bowlders to give increased depth and width. The improvement of this river will be substantially completed, as designed, to give 9 feet draught with the expenditure of $5,000, estimated for by me in Annual Report of Chief of Engineers for 1876, Part 1, pages 205, 206. This will require an appropriation of $3,000 in addition to the amount now available, which is asked for the fiscal year ending June 30, 1880.

A larger channel would be desirable, and no doubt will be asked for, but, with the completion of the improvement as originally designed, I do not feel authorized to estimate for anything more.

Taunton River is in the Fall River collection-district. The amount of revenue collected during the fiscal year ending June 30, 1878, was $18,970.05.

Money statement.

July 1, 1877, amount available	$100 93	
Amount appropriated by act approved June 18, 1878	2,000 00	
		$2,100 93
July 1, 1878, amount expended during fiscal year		100 93
July 1, 1878, amount available		2,000 00
Amount (estimated) required for completion of existing project		3,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880		3,000 00

B 6.

IMPROVEMENT OF PAWTUCKET OR SEEKONK RIVER, RHODE ISLAND.

No work has been done in this river during the past fiscal year. The remainder of the last appropriation is reserved to deepen certain shoals which are reforming, or for the removal of any accidental obstruction.

For a history of this work see Annual Reports of the Chief of Engineers for 1874, Part 2, page 227; and for 1876, Part 1, page 207.

Pawtucket River is in the Providence collection district, and that place is the nearest port of entry. The amount of revenue collected there during the fiscal year ending June 30, 1878, was $171,553.79.

Money statement.

July 1, 1877, amount available	$1,511 28
July 1, 1878, amount expended during fiscal year	127 75
July 1, 1878, amount available	1,383 53

B 7.

IMPROVEMENT OF PROVIDENCE RIVER AND NARRAGANSETT BAY, RHODE ISLAND.

Providence River is an estuary extending from Nayat Point, Narragansett Bay, to Providence. Its length is about 7 miles, with a width varying from 1,000 feet to 2 miles, and a depth from 12 to 50 feet at mean low-water. At its head this estuary is joined by another called the Seekonk or Pawtucket, extending 4 miles further to the town of Pawtucket. Providence has upward of 100,000 inhabitants, with large manufacturing and commercial industries. The legislature of the State has established harbor lines as far down as Field's Point, about 5½ miles above Nayat Point. The parts above Field's Point are called Providence Harbor. From Providence to the sea is about 28 miles, with ample width and depth below Nayat Point for the movement or anchorage of any number of the largest vessels.

The improvement sought is for a channel—

23 feet deep at mean low-water, 150 feet wide.
20 feet deep at mean low-water, 600 feet wide.
18 feet deep at mean low-water, 725 feet wide.
12 feet deep at mean low-water, 940 feet wide.
6 feet deep at mean low-water, 1,060 feet wide.

The general government has expended about $56,500 in the improvement of this harbor between Fox Point and Field's Point, making a depth

of 12 feet at mean low-water. In addition to this amount the city of Providence has expended upward of $90,000 in dredging the harbor, mainly above Fox Point.

Under date of February 18, 1878, I made a report in regard to the improvement of Providence Harbor and the channels of approach to it. This report was printed as Sen. Ex. Doc. No. 34, Forty-fifth Congress, second session, and is part of this report.

By act of Congress approved June 18, 1878, $50,000 was appropriated for the improvement of this river and bay. This it is proposed to expend in dredging a channel 23 feet deep in the shoalest part of the present channel, the work to be done by contract after advertising in the usual manner. By the same act of Congress $5,000 was appropriated for the removal of Bulkhead Rock. This rock is on the side of the deep channel of the river, about 2½ miles below Fox Point. It lies in the path of vessels beating in or out of the river and should be removed. In my former reports upon this obstruction I have estimated for its removal to a depth of 18 feet at mean low-water, at a cost of $5,000. At that time 18 feet was the governing depth, but with the depths of the proposed channel this should be removed down level with the bottom, about 20 feet at mean low-water. To do this will probably cost $10,000, and as it can be done cheaper by making the depth required at once, it is thought advisable to reserve the present amount until another appropriation for the river is made, when the work can all be done at once.

Providence is in the Providence collection district, and that place is a port of entry. The amount of revenue collected there during the fiscal year ending June 30, 1878, is $171,553.79.

Money statement.

Improvement of Providence River and Narragansett Bay.

Amount appropriated by act approved June 18, 1878	$50,000 00
July 1, 1878, amount available	50,000 00
Amount (estimated) required for completion of existing project	450,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880	100,000 00

Improvement of Providence River—removal of Bulkhead Rock.

July 1, 1877, amount available	$74 98	
Amount appropriated by act approved June 18, 1878	5,000 00	
		5,074 98
July 1, 1878, amount expended during fiscal year		74 98
July 1, 1878, amount available		5,000 00

SPECIAL REPORT ON IMPROVEMENT OF PROVIDENCE RIVER AND NARRAGANSETT BAY, RHODE ISLAND.*

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., February 25, 1878.

SIR: I beg leave respectfully to return herewith the resolution of the Senate of the United States of the 31st January last—

That the Secretary of War be directed to furnish to the Senate any information in his department relative to the improvement of Providence River and Narragansett Bay, with an estimate of the cost of such improvement,

* Printed as Sen. Ex. Doc. 34, Forty-fifth Congress, second session.

And, in obedience to its requirements, to submit the inclosed copy of report on the subject from Maj. G. K. Warren, Corps of Engineers, to hom it was referred. This report is very full, and conveys all the in-rmation contemplated by the resolution.

It will be seen that the improvement which, in the opinion of the har-r commissioners of the State of Rhode Island, is demanded by the erests of commerce, consists in making a channel of 23 feet in depth mean low-water from Providence to the sea, and they estimate that whole amount of dredging required for this purpose will be about 01,640 cubic yards, at a cost of $500,234.29. In this estimate no owance for rock-excavation is made, though it will in all probability in some places required.

The order in which the work of improvement should be executed is, Major Warren's opinion, first, to make the deep channel for ocean amers from Providence to the sea; then to proceed with the work of dening the channel, &c.

The cost of this deep channel he estimates at $100,000, and deems it be in the interest of economy to appropriate the whole sum at once. I concur in Major Warren's views.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brigadier-General and Chief of Engineers.

Hon. GEO. W. MCCRARY,
Secretary of War.

REPORT.

ENGINEER OFFICE, UNITED STATES ARMY,
Newport, R. I., February 18, 1878.

GENERAL: I have the honor to submit the following report in obedi-ce to your letter of instructions, of February 2, transmitting a copy of e resolution of the United States Senate, made on January 31, and so in obedience to your letter of February 7, transmitting a resolution the United States House of Representatives, passed on February 5, th in regard to the improvement of Providence Harbor, Rhode Island, d the channels of approach to it.

The House resolution requires a report "based on examinations and rveys made by the Coast Survey or other departments of the govern-nt," which, as far as I know, are as follows:

In the year 1872, under an act of Congress, I made a survey from Fox oint to Field's Point (see Annual Report of Chief of Engineers for 73, page 969), and estimated the cost of dredging off the point of Long d, for which $10,000 was appropriated, and the point dredged off in e summer of 1873.

In 1874 the United States Coast Survey made a new survey which also vered this portion of the harbor, and a copy of the map was furnished e Rhode Island Board of Harbor Commissioners, which copy I have nsulted. There is as close agreement in the result of the two surveys s could be expected, so that, as a basis for an estimate of quantity of aterial to be removed in this part, nothing more is desired. There is me uncertainty as to the amount of rock that may be encountered, but is cannot be definitely determined except as the dredging is being rried on.

During the past summer, upon application of the governor of Rhode

Island, the President of the United States appointed Rear-Admiral Daniel Ammen, chief of the Bureau of Navigation, United States Navy, Prof. Henry Mitchell, United States Coast Survey, and myself, members of an advisory council to the Board of Harbor Commissioners of Rhode Island, and this council had several meetings with the Harbor Commissioners to consider the improvement of Providence River and Harbor. The harbor proper is taken to comprise the part between Fox Point and Field's Point, a distance of about 8,800 feet. Through about 2,800 feet of this there is ample channel-depth. Through the other 6,000 feet the depth, in places, shoals to 14 and 15 feet, and at the upper end to 12 feet at mean low-water. This limits the size of the vessels that can reach the present wharves. The mean rise of the tide is about 4½ feet. In regard to the improvement of this portion the Advisory Council give the following opinion to the Harbor Commissioners:

In a port like Providence, employed for miscellaneous commerce, the greatest good to the greatest number is to be secured by a channel of 18 feet depth at low tide. In order, however, not to exclude vessels of greater draught, we recommend that the channel should have a central pathway of 23 feet depth, 150 feet wide.

The form of channel that would meet these requirements and have the most permanent slopes, would have the following widths, naturally, between its contours in light alluvium:

23 feet depth, 150 feet wide.
20 feet depth, 600 feet wide.
18 feet depth, 725 feet wide.
12 feet depth, 940 feet wide.
6 feet depth, 1,060 feet wide.

We recommend that this channel should be carried from the city to Field's Point, following generally the present channel below Fox Point; and using the above table as a guide as far as possible for computing the amount of material to be removed (and not as a convenient plan of dredging), we find from the original hydrographic sheet of the Coast Survey (1326 A), executed in 1874, that the necessary dredging would then have been two and one-quarter millions of cubic yards, bank measurement.

The average length of vessels likely to seek this harbor, if improved, may be set down at 150 feet, and these, with average draught of 18 feet, would require 54 feet of cable, giving her radius of swing room 202 feet. These vessels, anchored most carefully on both sides of the channel proposed, would leave 321 feet gangway for the passage of other vessels. If anchored with only the ordinary care (but still under supervision of a harbor-master) the width of the gangway would sometimes not exceed 150 feet. It is assumed that so few vessels of extraordinary draught would be in port at the same time that the harbor-master could so arrange them as to avoid having any two of them in the same section. It is proper to regard the vessels as lying transversely to the direction of the channel, because during the season when the largest fleet visits this port winds from the west-southwest and southwest prevail.

In providing for anchorage-room on either side of the gangway rather than excavating a special basin for anchorage, it has been borne in mind that the whole channel in the absence of vessels at anchor will be useful for the passage of vessels under sail, and that this channel traversed by tidal currents will be less likely to freeze up than a sheltered basin, or more easily broken out when frozen.

* * * * * * *

The Harbor Commissioners have also made an estimate of the amount of material to be removed to make a channel 23 feet deep at mean low-water, and 400 feet wide, with an additional width each side of 200 feet, gradually shoaling up to a depth of 10 feet at mean low-water. The amount is 1,421,720 cubic yards. But in their communication to me dated February 8, transmitted herewith, they adopt the plan and estimate of the Advisory Council.

In order to secure the depth of 23 feet at mean low-water below Field's Point, dredging must be done at Pawtuxet Shoal and at Gaspee Shoal.

The Harbor Commissioners' estimate for the amount to be removed at these two places, is upon the design to make the channel 23 feet deep and 400 feet wide and 200 feet each side, shoaling up to 10 feet.

At Pawtuxet Shoal, cubic yards	733,686
At Gaspee Shoal, cubic yards	46,000

In order to allow vessels to enter and leave Providence direct by the western entrance to Narraganset Bay, drawing 23 feet at mean low-water, another shoal must be removed just above Rocky Point, which the Harbor Commissioners estimate to amount to 424,824 cubic yards. Vessels using the middle entrance to Narraganset Bay, would not have to pass this shoal near Rocky Point. The foregoing quantities are bank-measurements; measured in scows, the quantity would be increased by one-third.

To recapitulate, we have now the following estimates of quantities:

ESTIMATE OF ADVISORY COUNCIL.

Fox Point to Field's Point, cubic yards, bank-measurement	2,250,000
Fox Point to Field's Point, cubic yards, measurement in scow	3,000,000
Cost	$428,571

ESTIMATES OF HARBOR COMMISSIONERS.

Fox Point to Field's Point, cubic yards	1,421,720
Pawtuxet Shoal, cubic yards	733,686
Gaspee Shoal, cubic yards	46,000
Rocky Point, cubic yards	424,824
Total bank-measurement	2,626,230
Total measurement in scow	3,501,640
Cost	$500,234 29

No rock is included in the foregoing estimates, and although some will undoubtedly have to be removed, as, for instance, Bulkhead Rock, this is comparatively a small item. This improvement, when made, will be permanent.

The improvement desired will, at present prices, cost about $500,000. The importance of doing this is so well set forth in the accompanying communication made to me by the Board of Harbor Commissioners that I have nothing to add on this point.

The first improvement to be undertaken is to make the deep channel for ocean-steamers, from Providence to the sea, and let the widening for anchorage and for a beating-channel for sailing-vessels follow. For making such a channel 200 feet wide and 23 feet deep at mean low-water I have estimated would require:

From Fox Point to Field's Point, 434,000 cubic yards, measured in scows.	
At Pawtuxet and Gaspee Shoal, 175,000 cubic yards, measured in scows.	
609,000 cubic yards, measured in scows.	
At $1 for 7 yards, this would cost	$87,000
Add for removal of rocks and superintendence	13,000
	100,000

To cut through the shoal near Rocky Point 200 feet wide and 23 feet deep at mean low-water would require the removal of 300,000 cubic yards, measured in the scows; and inasmuch as this shoal can be avoided by using the middle entrance to the bay, it is not an important obstruction. It now has a ruling depth of 18 feet at mean low-water.

All the estimates below Field's Point are based solely upon the United States Coast Survey charts, on one of which, sent herewith, the proposed channel is marked.

If the revenue of the government will allow such an expenditure in one year it would be best to appropriate the sum of $100,000 in one year, so that the benefit may be at once obtained.

Providence is in the Providence collection district and is a port of entry. The revenue from customs, during the fiscal year ending June 30, 1876, was $182,352.57.

The United States in former years has expended about $56,500 on improvement of this harbor.

Very respectfully,

G. K. WARREN,
Major of Engineers, Brevet Major-General, U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

COMMUNICATION FROM THE STATE BOARD OF HARBOR COMMISSIONERS.

SIR: We have received from you a communication, inclosing a resolution of the House of Representatives, of which the following are copies:

"ENGINEER OFFICE, UNITED STATES ARMY,
"*Newport, R. I., February* 8, 1878.

"SIR: I have just received the resolution of the House of Representatives of which the inclosed is a copy. The subject has been referred to me by the Chief of Engineers, United States Army, for report, with directions to confer with parties representing the interests involved. The matter, you know, has already been considered by us, so that its points are familiar. I wish, therefore, you would forward to me such report from your honorable Board as will represent the question in the light you regard it, to aid me in making my report, and to be transmitted with it to the Chief of Engineers. In its regular course it will probably be transmitted to Congress and printed for the use of the members in passing upon the subject itself.

"Yours, respectfully,

"G. K. WARREN,
"*Major Engineers, Brt. Maj. Gen., U. S. A.*

"Mr. J. HERBERT SHEDD,
"*Civil Engineer, President Rhode Island Harbor Commission.*"

"IN THE HOUSE OF REPRESENTATIVES,
"*February* 5, 1878.

"On motion of Mr. EAMES,

"*Resolved*, That the Secretary of War be, and he is hereby, directed to communicate to this House, as soon as practicable, what improvements, if any, are demanded by the interests of commerce for the improvement of navigation to the port of Providence, Rhode Island, based on examinations and surveys already made by the Coast Survey or other departments of the government, together with the estimated cost of such improvements."

In response to your request we respectfully submit the following:

The improvement of the navigation of this port for which we ask, and which we consider to be urgently demanded by the interests and for the safety of commerce, would be accomplished—

First. By widening and deepening the main channel from Fox Point, above and east of which (on the Providence and Seekonk Rivers) are our present wharves, to Field's Point, which is at the entrance to the inner harbor from Narragansett Bay. The distance between the two points by the thread of the channel is about 1⅛ nautical miles. There is deep water at both the upper and lower ends of this distance, but in the middle a bar exists having at points only 14 feet depth of water at low tide. A channel suited to this position should be about 1,060 feet in width between its outer banks, 150 feet of which width, in the center should be 23 feet in depth at low water and then of decreasing depths on each side to the outer banks, where this depth should be 6 feet at low water. This form of channel would meet all the requirements of the case. It would afford good anchorage-ground on each side of the central pathway, leaving a free course for the maneuvering or passage of vessels under sail.

Second. Below Field's Point within the bay, a continuous channel should be secured at least 800 feet in width, with a central pathway 23 feet in depth. This part of the work would necessitate the deepening of the natural channel at three points, to wit, opposite Rocky Point; about half the distance between Gaspee Point and the Pawtuxet beacon; and opposite the village of Pawtuxet. The channel should also be widened between a point nearly opposite Pawtuxet village and Field's Point. We should then have an unobstructed passage-way from the open sea to our docks for such heavy-draught foreign and coastwise vessels, and for such numbers of all draughts as would certainly seek our harbor if so improved.

As the streams emptying into the harbor are not of such size or character as to bring

; considerable amount of silt, it is quite probable that if the channel is once improved only a small annual outlay will be required to preserve its condi-

imated volume of material to be removed between Fox Point and Field's secure the desired channel is about 2,250,000 cubic yards, measured in bank. ork in the bay, the amonnt would be about 1,204,510 cubic yards.
hereafter appear by the contract prices for similar work for the city, there r no harbors where dredging can be more cheaply done; and as the proposed ient consists mainly of that kind of work, it follows that at comparatively t the chief obstacle to our advancement in commercial prosperity may be
We feel assured that the contemplated dredging can be done at the rate of ards for $1. If this work is done a continuous channel of about 30 miles in f 23 feet depth of water, from the sea to this port, may be secured.
y of Providence has peculiar advantages of location as an importing and ex-enter. Its outer harbor is Narraganset Bay, through one of the two unob-passages to which it can be entered by the largest vessels that float, in any any time, without a pilot; and it is never obstructed by ice to prevent making arbor. It is completely land-locked, and has about 70 square miles of anchor-re the entire shipping of all the ports of the United States could ride out any safety.
rbor proper of the city of Providence is an interior basin at the head of the ng an area of about 700 acres, with a channel leading up to the wharves. nel is obstructed by a bar having only 14 feet depth in places at low-water, ; stated.
y of Providence is the second in size in New England, and the sixteenth in the tates. It now contains a population of about 100,000, having made a very wth in the last ten years. It is the most northerly important terminus of convenient navigation from Southern ports, lying as it does about 30 miles nterior of New England, and having direct railroad communication with all hose States and the Canadas, and, by tapping the roads leading West, with producing States.
ne radiating center of supplies of raw material, as also the market, for an aggregate of manufacturing industries located immediately around it, and eveloped and sustained by the water-power of three streams. The leading nres are cotton and woolen goods, machinery, arms, &c., in which there are ,000,000 invested capital.
t-cloths there were reported sold here in 1877, a year of great depression in and therefore not a fair showing, 2,742,330 pieces.
erage annual sales during the previous ten years amounted to 4,614,733 pieces.
al reported receipts of cotton in this market, by all routes, during the year 1877, 532 bales, which is 18,746 bales less than the average during the previous six

al reported receipts of wool of all grades, by all routes, during the year were les and sacks, the average during the previous six years being 93,983 bales s per annum.
last census of Rhode Island it appears that our bleacheries and print-works l about 6,000 tons of supplies of foreign growth or manufacture; but there ulty in obtaining the facts, and the general belief is that these figures should ; increased.
nce is also the chief coal-port of New England. The total reported tonnage uring the year 1877 was 642,480 tons, of which 4,960 tons were foreign. The er annum during the previous six years was 580,587 tons, the foreign average 58 tons.
al reported receipts of flour during 1877 were 324,539 barrels, which is 38,477 ore than the average annual receipts of the previous six years.
nerefore, to the extent of our present transportation facilities, is an importan. and distributing point for direct importations and productions for export. wise traffic it is already the leading port in New England; and with our har-proved that ocean-steamers and coastwise vessels of the heaviest draughts ch our wharves, we should have unsurpassed facilities for becoming a com-; we already are a manufacturing center.
oastwise vessels now enter this bay and port than any other port in New Some of these of large draught of water, like the Philadelphia, Norfolk, more (freight) steamers, are at times compelled to wait hours for the full able them to cross the bar and reach the inner harbor.
hers are effectually barred from entering the port at all on account of the t depth of water in some parts of the channel, the inconvenient and expen-of which is that a considerable part of the freight consigned to our mer-manufacturers, besides that which would naturally come to this port in nterior points, must first be delivered in New York or Boston and then re-

shipped by rail to this port. One of the onerous features of this process is that the port-charges elsewhere are about twice as much as they are here, and this is one considerable item which counts with ship-owners in favor of this as a port of entry.

A pressing need of our present commerce is more anchorage-room, already large, to allow the channel to be kept free for the passage of vessels. As many as 70 to 75 vessels have come into the harbor in an afternoon, for all of which, with those already at anchor, there is not sufficient room. The result is a frequent blockading of the channel against the safe passage of vessels in and out of the harbor. Regular lines of passenger and freight steamers run daily between this and other ports, and in their passage through the channel much delay and danger sometimes result from the encroachments of anchored vessels lapping out over their course. This trouble is increased during the summer months when excursion-steamers loaded with passengers are passing in and out almost hourly.

The State does not ask that its maritime facilities shall be developed entirely at the expense of the United States Government. Its appreciation of the importance of preserving and improving the advantages it already possesses is shown by the expenditures which have been made to that end. The government of the city of Providence annually appropriates from $10,000 to $15,000 for the improvement of the harbor. A large amount of dredging has already been done in and about the upper part of the channel with the money thus appropriated, and sums paid by individuals; and now there is much more water in the harbor proper and around the docks than on the bars below.

During the last eight years $89,380.10 have been expended by the city for dredging alone, and for surveys, plats, &c., $2,474 more. This work has been done under very favorable conditions, the contract for last year for dredging about 168,000 cubic yards having been made at 9 cents per cubic yard.

The amount appropriated by the city for the current year is $15,000, and a contract for the dredging has been executed at 13 cents per cubic yard, requiring the material to be carried over trestle-work to fill flats belonging to the city.

The city has also nearly completed the removal at a cost of $60,000 of about 260,000 cubic yards of mud from the Cove Basin, so called, at the head of Providence River.

The chairman of the Harbor Committee of the city council has submitted a statement relative to the city's operations in the harbor, of which the following is a copy:

"PROVIDENCE, *January* 22, 1878.

"SIR: In reply to yours of the 10th instant, I would say that for many years the city has expended considerable sums upon dredging in the harbor, as will appear in the inclosed tabular statement.

"Our citizens and our city government fully realize the imperative necessity of increasing our harbor facilities, and a judicious and comprehensive plan for harbor improvement will assuredly receive cordial support.

"If only work could be done in the river and bay, below the point where the city could be asked to expend money, we might hope that our harbor would receive and our wharves accommodate the largest vessels.

"The following statement of money paid and work done on the harbor since 1870, is submitted and made a part of this communication.

For the year ending October 1—	Salary of harbor-commissioners.	Services for superintendence, &c.	Surveys, plats, &c.	Amount paid for dredging.
1870	$1,100 00	$763 00	.....	$16,583 10
1871	1,100 00	321 00	.....	9,532 81
1872	1,150 00	.....	.....	9,940 56
1873	1,300 00	.....	.....	5,621 13
1874	1,300 00	.....	$2,000 00	14,828 21
1875	1,300 00	.....	.....	10,016 28
1876	1,633 33	.....	.....	11,495 79
1877	1,800 00	535 00	474 00	11,362 22
	10,683 33	1,619 00	2,474 00	89,38 100

"In 1876 the appropriation for dredging the harbor was $11,500. The contract for dredging was given to S. A. Hammond, at 13 cents per cubic yard.

"In 1877 the appropriation was $12,500. The contract for dredging was awarded to Providence Dredging Company, at 9 cents per cubic yard.

"For 1878 the appropriation is $15,000, and contract for dredging awarded to Thomas Potter, at 13 cents per cubic yard.

"These low prices have been obtained notwithstanding the fact that there has been xtra trouble to the contractor in disposing of the material. Last year about half the aud was towed 16 miles to a dumping-ground, and for the year to come the price inludes the cost of transferring the material by cars, on trestle-work, to ground too high o be reached in scows. This is required in order to develop wharf-property.

"Very respectfully, yours,

"ARTHUR T. DEXTER,
"*Chairman, for Committee on the Harbor.*

"J. HERBERT SHEDD, Esq.,
"*Chairman of the State Board of Harbor Commissioners.*"

We submit a copy of resolution passed by the Providence Board of Trade:

"The following preamble and resolutions were read and unanimously adopted at the nnual meeting of the Providence Board of Trade, of the city of Providence, R. I., eld January 9, 1878:

"Whereas this city is situated at the head of Providence River, affording a broad, afe, and natural approach to a point about 30 miles inland, from which a large porion of the New England States may be conveniently reached; and

"Whereas much shipping is prevented from coming to this port on account of the oal channels leading to the harbor, notwithstanding our city government has already xpended considerable sums of money in widening and deepening the channels of the arbor: Therefore,

"*Resolved*, That in the opinion of this Board it is desirable and necessary that steps e taken to procure aid from the United States Government to enable the improvement be made, so that the natural facilities of this harbor may be properly developed and ncreased.

"*Resolved*, That the president of this Board be, and he is hereby, appointed a committee to confer with the State Board of Harbor Commissioners, and is requested to ooperate with said Board in urging upon the United States Government the importnce of the work and procuring the necessary aid therefor.

"PROVIDENCE, *January* 29, 1878.

"I hereby certify the foregoing to be a true copy and record.

"F. P. LITTLE,
"*Secretary.*"

The Board of Trade adopted another resolution, as follows:

"*Resolved*, That the president of this Board be authorized to appoint a committee to ertain the amount of foreign and domestic goods annually brought into this disict."

The committee made the following report:

"Your committee were notified of their appointment on the 23d ultimo; they were alled together immediately, and have held several meetings to consider the business nfided to them.

"The difficulties in the way of obtaining such information as is desired are many. he want of time precludes the possibility of issuing circulars to our merchants and anufacturers requesting such information as would enable us to estimate accurately e amount of material required in their business, and had the time been sufficient the luctance of many of our manufacturers to give such information would have renered a report thus obtained inaccurate.

"The last census of Rhode Island, taken under the charge of a most faithful and ficient superintendent, gives the capital employed in manufactures (that is, value of al estate and machinery) as $49,942,871; of raw material used, $76,715,970; of prodcts, $126,659,875. Under the head of special manufactures, we find that there were ported to have been used in print-works and bleacheries about 6,000 tons of material f foreign growth or manufacture. From information received from other sources the st item is believed to be much too small, and the same discrepancy may exist in other gures.

"So far we have spoken only of supplies required in our manufactures; there is no ssible means of obtaining an account of supplies required for all other branches of dustry, and for a population of 258,239 persons.

"Were it possible to obtain ever so correct an account of the wants of the people of ur own city and State, we should still be far short of the information of which we re in search.

"Providence Harbor is the natural source of supply and the natural outlet for all of he country lying east of the Connecticut River, north to the Canada border and west f Boston; in fact, coming from the South, Providence is nearer by steam by 24 hours han the harbor of Boston, and when we consider the dangerous navigation around Cape Cod, we are led to believe that with sufficient depth of water in our bay and harbor, the Boston lines from the South would find it for their advantage to make Provi-

dence the terminus of their voyage, and transfer by rail such parts of their cargoes as may be destined for Boston.

"With a view to estimating the number of tons of merchandise that is annually going to and from and through this city, we have requested from our several railroad companies, and from the New York, Philadelphia, and Norfolk lines of steamers, an account of the number of tons of merchandise transported by them during the past year.

"The tonnage on the railroads is given in total, as there is no means of ascertaining how much may go from point to point on the roads, without touching this city; but when we consider that in this statement there is no account taken of the amount carried by the smaller lines of steamboats, by sailing-vessels, and by teams, we may not form a very inaccurate idea of the business of this port, even in dull times, and when the bars in our bay prevent us from receiving a very large part of the business that the position of our city would otherwise give us.

"The accounts received from the railroads and steamboats are as follows:

	Tons.
Providence and Springfield	37,957
Providence, Warren, and Bristol	47,036
Providence, Hartford, and Fishkill	296,681
Providence and Stonington	226,945
Boston and Providence	631,850
Providence and Worcester	641,135
Windsor Line to Philadelphia	48,254
Providence, Norfolk, and Baltimore	105,600
Providence and Stonington Steamship Company (boat direct)	375,000
Total tons	2,410,488

"The records of the custom-house show that during the past year there have been 123 foreign and 5,520 domestic arrivals; that the value of imports was $466,868; that there were brought by water 201,699 bales of cotton, 37,745 bales of wool, 60,362 barrels of flour, 685,336 bushels of grain, and 642,480 tons of coal.

"It is estimated by competent authority that the wholesale grocery business of this city amounts to $11,000,000 per annum, and that of this amount $7,300,000 is in goods of foreign growth. The trade in drugs and chemicals, which is very largely in merchandise of foreign growth or manufacture, is estimated at about $5,000,000 per annum.

"The domestic importations of Providence by railroad and by water for 1877 are given as follows: 234,532 bales of cotton; 324,539 barrels of flour; 1,549,096 bushels of corn; 586,905 bushels of oats; 642,480 tons of coal.

"Respectfully submitted.

"JAMES SHAW, Jr.
"GEORGE W. WHITFORD.
"BENJAMIN W. PARSONS."

As illustrating the delays resulting from the shallowness of water on the bar, we insert the following copy of a letter received from the agent of one of our principal steamship lines:

"PROVIDENCE, NORFOLK AND BALTIMORE STEAMSHIP LINE,
"*Providence, R. I., February* 14, 1878.

"DEAR SIR: I beg and desire to call your attention to the fact that in the year 1873 the Merchants and Miners' Transportation Company of Baltimore, Md., inaugurated a line of steamships between Baltimore, Norfolk, and Providence, and styled it the 'Providence, Norfolk and Baltimore Steamship Line.' Since this line was set in motion, owing to the great draught of water of our steamers, we have met with very serious delays on account of the depth of water in our harbor. The steamers of this line, when full-freighted, draw 18 and 20 feet of water, and have touched bottom in midway of channel, and dragged the bottom for long distances; and when we have had strong northwest winds we experience very much more delay. If our steamers arrive on an ebbing tide of 2 or 3 hours' duration and ground, they are obliged to so remain until the full flood-tide makes again, causing the loss of valuable time, from 6 to 8 hours, which is exceedingly annoying to our patrons and ourselves. I will here state that the Merchants and Miners' Transportation Company also run a line of steamers between Baltimore, Norfolk, and Boston, via Cape Cod, and I have often advocated to them of their making the terminus of the Boston steamers at Providence, and connect with Boston by railroad; but our company has always contended that it was not practicable to do so with their largest steamers, on account of the shallowness of the water in our harbor, but have intimated to me that if harbor facilities were such at Providence that no delays would occur on account of depth of water, and the steamers could arrive and depart at any time of tide, that ultimately the terminus of the Boston line would be established at Providence. This line is an important one

r the city of Providence, running, as it does, direct to the South, connecting at Nor-k, Va., with the Virginia and Tennessee Air-Line and Seaboard and Roanoke Rail-ds for all points south, and at Baltimore (Locust Point), Md., with the great Balti-re and Ohio Railroad for all points west, north, and southwest.

'I trust that some special action will be taken by the State this present year to prove the navigable waters of our beautiful Narraganset.

"Very respectfully, yours,

"E. H. ROCKWELL,
"*Agent Providence, Norfolk and Baltimore Steamship Line.*

'J. HERBERT SHEDD, Esq.,
"*Chairman of the Harbor Commissioners.*"

he following tabular statement has been furnished to us by General Shaw, collector his port:

Commercial statistics of Providence, 1871 to 1877.

	1871.	1872.	1873.	1874.	1875.	1876.	1877.
ign arrivals	205	182	175	170	91	90	123
e of imports (dollars)*	652, 281	780, 616	818, 323	412, 698	552, 768	288, 454	466, 868
twise arrivals	5, 808	6, 542	6, 952	4, 665	6, 373	5, 326	5, 520
Bringing—							
s of cotton	182, 598	198, 325	299, 364	254, 235	178, 446	218, 267	201, 699
s of wool	55, 137	43, 540	149, 561	47, 278	37, 891	39, 904	37, 745
els of flour	145, 375	131, 713	171, 048	261, 920	161, 486	88, 682	60, 362
els of grain	751, 553	886, 058	876, 617	942, 290	822, 009	716, 830	685, 334
of coal	548, 669	699, 188	709, 784	600, 386	691, 847	610, 359	642, 480
TONNAGE.							
els	92	85	129	123	128	131	131
	21, 090	19, 115	22, 489	25, 977	34, 107	35, 107	36, 611

* Foreign value in gold.

JAMES SHAW, Jr.,
Collector.

l of which is respectfully submitted.

J. HERBERT SHEDD,
N. F. POTTER,
JEDEDIAH WILLIAMS,
Harbor Commissioners.

neral G. K. WARREN,
Major of Engineers, U. S. A.

B 8.

IMPROVEMENT OF NEWPORT HARBOR, RHODE ISLAND.

othing has been done here during the past fiscal year, and no work ntemplated during the next. The small amount of funds available he beginning of the year has been expended in closing up the work office expenses.

Money statement.

1, 1877, amount available	$30 14
1, 1878, amount expended during fiscal year	30 14

B 9.

IMPROVEMENT OF BLOCK ISLAND HARBOR, RHODE ISLAND.

Block Island is situated about 12 miles from the nearest point on the inland. Its nearest natural harbor is in Narragansett Bay, some 25

miles distant. The island is about 9 miles long and about 4 wide in its widest part. Its population is about 1,400. The improvement sought was the building of a harbor for larger boats than were heretofore used by the fishermen and for such as would be employed in bringing coal, lumber, &c., and for otherwise facilitating communication between the island and the mainland.

At the beginning of the present fiscal year the main work had been built out to a point 1,325 feet from the shore and the inner harbor with an inclosed area of about 1½ acres, and 7 feet depth at mean low-water, completed. At that time stone was being put into the work by Messrs. P. Harrington & Co., of Groton, Conn., under contract at $1.29 per ton. They continued until the completion of their contract, November 30, 1877, having put in from the first 34,268.73 tons; of this amount 25,227.38 tons were put in from July 1 to November 30. They were enabled to put in this large amount in so short a time by employing a large number of vessels and getting the stone from two or three quarries. The building of a detached piece gave them places to unload three or more vessels at the same time.

During August and a part of September a vessel with divers was employed in removing bowlders from the anchorage sheltered by the breakwater. There were removed 517 tons, at a cost of $2.20 per ton for those up to 10 tons and $6 per ton for those in excess of this size.

The condition of the work at the close of the season was as follows: The breakwater extending out 1,425 feet from the shore, an opening of 200 feet, and then a detached pier 300 feet in length, the first 50 feet in prolongation of the main work, the second 50 feet on a line making an angle of 15 degrees to the left, and the remaining 200 feet on a line making an angle to the left of 15 degrees with the second 50 feet.

Our experience in the construction of the work thus far has shown that whenever large quantities of stone have been put in during the season of mild weather it has always been displaced and settled down by the storms of winter. This had occurred while the work was in much shoaler water than that built during last season. In view of this probability, sufficient funds were reserved to build up the work after the storms of the winter.

During the winter there occurred several quite severe storms, but on the 10th of January an unusually severe one visited this section. At the time of high-water the waves rolled in over the beach in the angle to the east of the inner harbor with sufficient height and force to carry stone weighing 40 to 50 pounds over the parapet of the east crib into the basin. This parapet is about 8 feet above mean high-water.

An examination of the work in April showed that the head of the main work and the detached piece, all built last season, had been settled down considerably by these storms. The greater part of the change of form and settling seemed to be confined to the outer or most exposed ends of the work. It was estimated that it would require 3,000 tons to build this up to the required height and form.

Advertisement inviting proposals to furnish and place this stone was made April 25, 1878, and on the 25th of May the following were received:

f proposals received at the Engineer Office, United States Army, Newport, R. I., 25, 1878, at 10 a. m., for riprap granite for breakwater at Block Island, R. I.

Name of bidder.	Address.	Commence.	Complete.	Price per ton of 2,240 pounds.	$4,000 will pay for tons.
is H. Smith	New York City	June 1	July 31	$1 14	3,508
B. Chapel	Waterford, Conn	June 1	July 31	1 28	3,125
Scully & Co	Groton, Conn	June 1	July 31	1 44	2,777
A. Sylvester	Quincy, Mass	June 1	July 31	1 48½	2,693
Ingerson and W. H. Molthrop	New London, Conn	June 1	Aug. 1	1 65	2,424
Edsall	New York City	June 1	July 31	1 66	2,409

ntract was awarded to the lowest bidder, Mr. Francis H. Smith, York, at $1.14 per ton.

was commenced in the latter part of the month, and up to the nt 275 tons had been put in. It is expected that the contract ompleted by August 31, 1878.

ill complete the breakwater for a harbor for local purposes at a 285,000. We have been enabled to do this at a much less cost imated, by dispensing with the cut stone, using only riprap and by reason of the fall in prices for such work.

sland is in the Newport collection district, which place is a port of entry. ue collected during the fiscal year ending June 30, 1878, is $1,466.41.

Money statement.

7, amount available	$46,978 96
8, amount expended during fiscal year	41,424 24
8, amount available	5,554 72

B 10.

MENT OF PAWCATUCK RIVER, RHODE ISLAND AND CONNECTICUT.

rk has been done here during the past fiscal year, and none is lated during the next. The small amount of funds available at nning of the year has been expended in closing up the work and expenses.

Money statement.

77, amount available	$101 97
78, amount expended during fiscal year	101 97

B 11.

EMENT OF LITTLE NARRAGANSETT BAY, RHODE ISLAND AND CONNECTICUT.

bay lies between Stonington, in the State of Connecticut, and Hill, in Rhode Island. It is entered from Fisher's Island Sound,

and it receives the waters of Pawcatuck River, at the head of navigation of which are the flourishing towns of Pawcatuck, Conn., and Westerly, R. I., with their mills and fine granite quarries. The general government has already dredged a channel-way in the river up to these towns, 75 feet wide, 5½ feet deep at mean low-water, and 8 feet deep at mean high-water. The entrance to the bay is deep, but a shoal extends all across its wider portion, which cannot be passed at mean low-water with vessels drawing more than 4½ feet or 7 feet at mean high-water, and it was besides obstructed with dangerous rocks. The bay was surveyed by authority of the general government in 1875, and is reported on, with project for improvement, in Annual Report of Chief of Engineers for 1876, Part 1, pp. 217–221. The project was for a channel 7½ feet deep at mean low-water, and 200 feet wide, together with the removal of the dangerous rocks. The reason for making it deeper than the channel made in the river is to enable vessels to pass it in the earlier stages of the tide, and thus insure reaching Westerly on the crest of the tide-wave. The estimated cost was $51,000.

The act of Congress approved August 14, 1876, appropriated $5,000 to begin this improvement, but the expenditure was not ordered until May, 1877. Of this amount $1,500 was set aside for superintendence and for removing dangerous rocks near Rhodes' Folly by hired labor, and $3,500 for making the proposed channel near Pawcatuck Point, by contract with the lowest responsible bidder. Pawcatuck Point was selected because part of the material to be removed from the place was known to be bowlders, while all the other parts were soft digging. It was desirable to test the feasibility of the whole plan at once by operations upon the most difficult part. There was the additional reason that if a channel were opened here it would be available with nearly as much water in other parts as the route heretofore used and with better steering ranges and less dangers.

It is reported in the last annual report (Part 1, page 204) that the contract had been awarded to W. H. Molthrop, of New London, Conn., to remove the material, including bowlders of a size not exceeding one cubic yard, at the rate of 30 cents per cubic yard, and all bowlders of a greater size at the rate of $5 per cubic yard.

The dangerous rocks near Rhodes' Folly having upon them a less depth than 7½ feet at mean low-water, have all been removed by hired labor. The amount was 131 cubic yards. One rock weighing, probably, 150 tons had to be blasted, and the pieces, as well as the other rocks, were lifted by scows under the action of the rising tide.

Work near Pawcatuck Point was begun July 4, 1877, by a very poor dredging-machine, which two days after hauled off for repairs. Another dredge was obtained September 24, and this continued until December 17, when work was abandoned for the winter. The time of completion was extended from November 30, 1877, to June 30, 1878. The dredge resumed work on the 3d of June and continued till the 17th of that month, when her boiler burst, fortunately without serious injury to the crew. Nearly all the work had now been done that the funds would pay for, and the object of testing the character of the excavation having been accomplished, I regarded the contract as completed.

Two cuts, having a combined width of 34 feet, have been made across the shoal at the point, and another cut about one-third of the way in the part where the dredging is easiest. A ridge of bowlders was encountered running across the new channel, having a width of about 50 feet. About half of these were larger and the other half smaller than one cubic yard. About 69 cubic yards of the large size were removed

per yard. The other material removed amounted to 4,015 cubic at 30 cents.

e new channel is too narrow to be of any use as yet. It is proposed pend the appropriation of $10,000 approved June 18, 1878, along the remainder of the former appropriation, in completing the chan- pposite to Pawcatuck Point to the width of 200 feet and depth of t at mean low-water, and to commence the deepening of the chan- est of this, if there is money enough.

original estimate was for $51,000, of which $15,000 has been appro- d. The remainder, $36,000, is asked for the next fiscal year.

improvement is in both the collection districts of Providence, R. I., and Ston- Conn. The revenue collected at the first named during the last fiscal year is 1.79.

October and November, 1877, a set of tide-observations was made fy the mean low-water plane at Watch Hill, established in making rvey in 1875. The difference in the mean rise and fall of tide was ot.

bench-mark at Pawcatuck Point, to which mean low-water is re- is a bolt in the south face of the largest bowlder on the southwest Pawcatuck Point at the low-water line. It is 3.07 feet above low-water. Simultaneous observations were made at Westerly awcatuck Point to get a mean low-water for the upper part of the tuck River, the bench-mark to which the old mean low-water plane ferred having been carried away by ice. The new bench-mark is of the cap-log at southeast corner of Cottrell and Babcock's Wharf, tuck.

marked ◇B. M◇, and is 5.19 feet above mean low-water. This rement has been superintended by Mr. H. A. Bentley, Assistant eer.

following is a table of the observations made at Pawcatuck

Date.	High-water.	Low-water.	Date.	High-water.	Low-water.
1878.	*Feet.*	*Feet.*		*Feet.*	*Feet.*
0	10.60	8.0	November 3	10.30	7.10
1	10.90	8.10	November 4	9.60	6.70
2	10.70	8.20	November 5	10.90	7.40
3	11.70	7.80	November 6	10.80	6.70
4	10.30	7.80	November 7	10.50	7.00
5	11.00	7.90	November 8	10.70	7.80
6	11.60	8.50	November 9	10.80	8.10
7	10.90	8.00	November 10	10.20	8.00
8	10.50	8.20	November 11	10.70	8.80
9	10.40	8.30	November 12	10.20	8.70
0	10.10	8.00	November 13	10.00	8.50
1	11.10	8.20	November 14	9.80	8.20
r 1	10.70	8.0	November 15	9.70	7.80
r 2	11.10	8.50	November 16	9.80	8.00

Mean rise and fall of tide 2.63 feet.

Money statement.

1877, amount available	$5,000 00	
t appropriated by act approved June 18, 1878	10,000 00	
		$15,000 00
1878, amount expended during fiscal year		4,320 62
1878, amount available		10,679 38
t (estimated) required for completion of existing project		36,000 00
t that can be profitably expended in fiscal year ending June 30, 1880		36,000 00

B 12.

IMPROVEMENT OF CONNECTICUT RIVER BELOW HARTFORD, CONNECTICUT.

The improvement under this heading consists of two essentially different kinds of work:

First. The removal of the shoals that form every year during flood stages between Middletown and Hartford, a distance of about 16 miles. The most important ones are known as Hartford Bar, Pratt's Ferry Bar, Glastenbury Bar, Dividend Bar, and Pistol Point Bar. The Hartford Bar and Glastenbury Bar have required dredging every season. That at Glastenbury has required more than all the others combined. It seems called for to make a special survey to see if some permanent work can be done that will avoid this large annual expenditure. The object of removing these bars is to secure a draught of 9 feet at low-water to Hartford, and for this purpose a channel about 60 feet wide has to be dredged through varying distances. An annual appropriation of about $5,000 is thus required.

Second. To deepen the water at Saybrook Bar and also to render its passage more easy and less dangerous. In its natural condition its mean low-water depth, about 6 feet, limited the draught of steam-vessels which had to enter without regard to stage of tide. The improvement attempted has been to deepen the water on the bar by confining its action by means of stone jetties, the littoral current of the sound tides preventing any extension of the bar.

The improvement of the upper part between Middletown and Hartford has always been the most needed, and no money has been expended on Saybrook Bar until the other was attended to. Even at the bar the removal of wrecks lying in the usually navigated channel has been of more importance than work on the jetties, and these latter have only been extended by the surplus of appropriations not needed for the other purposes.

At the beginning of the fiscal year dredging was being done on the bars below Hartford by a dredge hired by the day, and the wreck of the schooner E. J. Meany was being removed from Saybrook Bar by contract. The removal of this wreck was completed July 25, 1877.

There were no funds remaining to do any work upon the jetties at Saybrook Bar during the fiscal year.

Dredging was continued on the bars above Middletown until September 30, 1877. There were removed from Glastenbury Bar in this time 14,231 cubic yards, making a channel 60 feet wide and about 40,000 feet long, with a depth of 9 feet at low-water. With the 3,617 cubic yards removed in June, 1877, reported in my last annual report, there were removed from this bar, during the season of 1877, 17,848 cubic yards of material at a cost of $5,387.50, or 30.2 cents per cubic yard. There were removed from Hartford Bar 2,202 cubic yards of material at a cost of $473.50, or at a cost of 21.5 cents per yard.

The total cost for dredging was $5,860, to which should be added $640 for superintendence, making the cost for the season of 1877, $6,500.

In May, 1878, the water had fallen so low that the boats began to touch on the bars. Under date of May 24 authority was asked to employ a dredge, tug, and scow, at a rate not to exceed $75 per day, to be employed when needed. This was granted May 28, and a dredge put to work on the 29th on Glastenbury Bar. On the 1st of July she

had dredged 6,426 cubic yards on making a channel 1,310 feet long, 50 feet wide, and 9 feet deep at low-water.

By the act of Congress approved June 18, 1878, $30,000 was appropriated for the river below Hartford. Of this, $2,000 is to be expended at the mouth of Salmon River. It is proposed to do this, deepen the shoals between Middletown and Hartford where necessary, and extend the jetties on Saybrook Bar to its outer edge.

For continuing the work on the Saybrook Bar and dredging the shoals between Middletown and Hartford an additional appropriation is asked.

The importance of improving this portion of the river will be increased with the improvement of the portion above Hartford.

This part of the river is in the Middletown collection district, which place is a port of entry. The revenue collected during the fiscal year ending June 30, 1878, is $10,929.97.

Money statement.

July 1, 1877, amount available	$10,713 75	
Amount appropriated by act approved June 18, 1878	30,000 00	
		$40,713 75
July 1, 1878, amount expended during fiscal year		8,569 07
July 1, 1878, amount available		32,144 68
Amount (estimated) required for completion of existing project		30,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		30,000 00

B 13.

IMPROVEMENT OF CONNECTICUT RIVER ABOVE HARTFORD, CONNECTICUT, AND BELOW HOLYOKE, MASSACHUSETTS.

According to the recommendation in the last annual report, all the reports heretofore made were combined and publication with the diagrams ordered by the House of Representatives during its last session.* This is in a measure due to the increasing appreciation of the importance of transportation by water along the river. It is hoped that more systematic and enlarged appropriations will be made hereafter in prosecuting the improvement if it is expected that any large results will be produced. This portion of the river is divided into two natural divisions. The first is from Hartford to the foot of the Enfield Rapids, a distance of 10¾ miles. In low water the shoals at Barber's Landing Bar do not give a depth of more than 18 inches, and we are at present putting in wing-dams, with the expectation of increasing the depth to 3 feet. The depths on two bars situated above this one were thus increased in 1871, and it has since remained. This enables light-draught vessels of small size to reach Windsor Locks, at the foot of the Enfield Falls, and to there pass through the canal (by paying toll to the owners) and on up the river to Springfield and Holyoke. If the design is to only make this little use of the river the present appropriations are ample, and nothing is needed for the river "on or above Enfield Falls and below Holyoke," for which an appropriation has been made, and which portion forms the *second division* of the river above Hartford.

If the design is adopted to make a low-water depth of 6 feet between Hartford and the Enfield Falls, either a canal must be built or the river thoroughly rectified, which the estimates already made show will cost

* House Ex. Doc. 101, Forty-fifth Congress, second session.

about $1,000,000. For this purpose the present rate of appropriating is quite insufficient, and not less that $100,000 a year will be required. This is the estimate I have submitted below for this part of the river for the next fiscal year.

In the money statement in the part appropriated we have included parts on hand of two appropriations applicable to this part of the river.

The appropriation for the part "on and above Enfield Falls and below Holyoke" is too small to begin the new canal around the falls with. I have made a separate statement of this, and estimated for an appropriation of $200,000 with which to commence this canal and locks.

The work during the fiscal year has been to complete the combined report and to make a contract for building the wing-dams at Barber's Landing Bar. The following is an abstract of proposals received after duly advertising:

Abstract of proposals received June 4, 1878, at 10 a. m., for building two stone wing-dams at Barber's Landing Bar, on the Connecticut River near Hartford, Conn.

Name.	Address of bidders.	Commence.	Complete.	Price per cubic yard.	Estimated amount will cost.
Sidney Edsall	New York City	June 15	Nov. 30	$2 11	$3,165
C. C. Goodrich	Secretary for Hartford and New York Transportation Company	May 5	June 5	2 75	4,125
Michael O'Neil	Hartford, Conn	June 15	Nov. 30	4 15	6,225

A contract was entered into with Mr. Sidney Edsall, the lowest bidder.

Connecticut River above Hartford and below Holyoke is in the Middletown collection district. Middletown is the nearest port of entry. The amount of revenue collected there during the fiscal year ending June 30, 1878, was $10,929.97.

Money statement.

Above Hartford and below Enfield Falls, Connecticut.

July 1, 1877, amount available	$15,562 47
July 1, 1878, amount expended during fiscal year	629 71
July 1, 1878, amount available	14,932 76
Amount that can be profitably expended in fiscal year ending June 30, 1880	$100,000

On or above Enfield Falls, Connecticut, and below Holyoke, Massachusetts.

July 1, 1877, amount available	$10,702 92
July 1, 1878, amount available	10,702 92
Amount (estimated) required for completion of existing project	835,801 00
Amount that can be profitably expended in fiscal year ending June 30, 1880	200,000 00

B 14.

SURVEYS AND EXAMINATIONS OF CONNECTICUT RIVER.*

WAR DEPARTMENT,
Washington City, June 10, 1878.

The Secretary of War has the honor to transmit to the House of Representatives, in response to the resolution of the House dated April 24,

* Printed as House Ex. Doc. 101, Forty-fifth Congress, second session.

1878, copy of a report in detail from Brevet Maj. Gen. G. K. Warren, major Corps of Engineers, "of the surveys and examinations of the Connecticut River between Hartford, Conn., and Holyoke, Mass., made since 1867, under the direction of the War Department."

The suggestion of the Chief of Engineers is concurred in, that the report in full, with its diagrams, be published.

GEO. W. MCCRARY,
Secretary of War.

The SPEAKER *of the House of Representatives.*

LETTER OF THE CHIEF OF ENGINEERS.

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., June 8, 1878.

SIR: I beg leave to return herewith the resolution of the House of Representatives of April 24, 1878, which was referred to this office for report, viz: "That the Secretary of War be requested to furnish to the House of Representatives, as soon as practicable, a report in detail of the surveys and examinations of the Connecticut River between Hartford, in Connecticut, and Holyoke, in Massachusetts, made since 1867, under the direction of the War Department," and in compliance with its requirements to submit the accompanying copy of a report from Bvt. Maj. Gen. G. K. Warren, major Corps of Engineers, the officer under whose supervision the improvement of the Connecticut River is now being carried on.

General Warren's report is very full, and it is believed will furnish all of the information contemplated by the resolution.

I concur in his suggestions that the report in full, with its diagrams, be published.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brigadier-General and Chief of Engineers.

Hon. GEO. W. MCCRARY,
Secretary of War.

REPORT.

ENGINEER OFFICE, UNITED STATES ARMY,
Newport, R. I., May 4, 1878.

SIR: The matter of "a report in detail of the surveys and examinations of the Connecticut River between Hartford, in Connecticut, and Holyoke, in Massachusetts, made since 1867, under the direction of the War Department," having been referred to me to furnish the necessary information, I have the honor to submit the following:

In the act making appropriations for the "repair, preservation, &c., of certain public works, * * * and for other purposes," approved March 2, 1867, was an appropriation "for examinations and surveys" at places named in the fourth section of the act, one of which was the Connecticut River between Hartford and its mouth. (See Stat. at Large, vol. 14, p. 418.)

The report of this examination and survey was transmitted to Congress in February, 1868, and is printed as H. Ex. Doc. No. 153, Fortieth Congress, second session. Brevet Col. D. C. Houston, Corps

of Engineers, directed this work, assisted by Mr. Theodore G. Ellis, civil engineer, the latter conducting the operations in the field and furnishing the detailed report. The estimated cost of improvements below Hartford was $70,000. No report is made concerning the part of the river above, except in Ellis's report, on page 10, where, under the heading "Character of the river," a general description of the river is given. This report is republished in the Annual Report of the Chief of Engineers for 1868, Appendix P 3, pp. 754–784.

The act making appropriations for rivers and harbors, approved July 25, 1868, made no provisions for improving the Connecticut River. (See Stat. at Large, vol. 15, p. 171.)

The act for the same purpose, approved April 10, 1869, also made no appropriation for the Connecticut River. (See Stat. at Large, vol. 16, p. 44.)

The act for rivers and harbors, &c., approved July 11, 1870, appropriated "for improvement of Connecticut River, forty thousand dollars." (See Stat. at Large, vol. 16, p. 223.)

The changes of stations of engineer officers in June, 1870, brought this improvement under the charge of the writer of this report.

It should be noted in regard to this appropriation, that inasmuch as there had been no estimate made by the Engineer Department, under provisions of law, for an improvement of the Connecticut River, except below Hartford, and that inasmuch as the amount appropriated by the act approved July 11, 1870, was less than that estimate, it was reasonable to think that, in the absence of any mention of specific place of application of the money, it was all intended for the part below Hartford. The Hon. P. Sawyer, member of the House from Wisconsin, however, informed the Engineer Department that it was understood among the members of Congress interested in the Connecticut River improvement that half of the appropriation was to be used in Massachusetts and half in the State of Connecticut. Inquiry among those members showed that this was their understanding, and consequently only $20,000 was allowed to the part of the Connecticut River below Hartford. The condition of the matter up to this time was given in the Annual Report of the Chief of Engineers for 1870, at pp. 74, 75, and in Appendix U, pp. 446–448.

The continuation of the somewhat complicated account of the improvement of the river above Hartford (in which the questions of surveys and examinations and of improvements are difficult to separate) was given in the Annual Report of the Chief of Engineers for 1871, p. 85, and in the Appendix T 8, pp. 756–758. From page 761 I quote the following:

> A little investigation showed that the idea of improvement which would jump the space between Hartford and the boundary of Massachusetts and begin work in that State, must have arisen from some misapprehension. The navigation as it is between Hartford and the Massachusetts line is so bad that any improvement above, while this remains the same, would be nearly worthless.
>
> I therefore addressed a letter to the Hon. S. W. Kellogg, member of Congress from Connecticut, requesting him to confer with the other members of Congress interested in the improvement, and inform you (the Chief of Engineers) whether the understanding was not that the improvement should be made by expending half the appropriation of $40,000 above Hartford, and half below.
>
> On the 19th of December, 1870, I received a communication from you (the Chief of Engineers), dated December 16, stating that former restrictions upon the appropriations were withdrawn, and that I was authorized to expend it, or as much of it as I deemed necessary, above Hartford.
>
> Accordingly, on the 20th of December, I gave orders to General Theodore G. Ellis, civil engineer, my assistant, to make a report on the navigability of the Connecticut River as far up as the north boundary of Massachusetts, and survey such parts above Hartford as it was best to improve with the $20,000.

These examinations and surveys were prosecuted in the depth of winter, and his report was submitted to me dated March 4, and transmitted with a report from me dated March 15, 1871.

The plan decided upon by this report was for disbursing the $20,000 between Hartford and the Enfield Falls, and requiring for wing-dams, &c., about $17,000. The remainder, $3,000, was required to make the surveys and engineering plans. The wing-dams were to be as follows:

At Higley's Point, 600 cubic yards of stone, at $3	$1,800
At Barber's Landing, 900 cubic yards of stone, at $3	2,700
At Tunxis River Bar, 700 cubic yards of stone, at $3	2,100
At Strong's Island, 560 cubic yards of stone, $3	1,680
At Scantic River, 2,880 cubic yards of stone, $3	8,640
For removal of stumps	80
	17,000

General Ellis estimated roughly that a suitable dam and lock for passing the Enfield Falls, independent of the locks and canal belonging to the present water-power company, would cost $850,000.

The foregoing-named reports by myself and my assistant, General Ellis, are the first of the examinations and surveys made on the Connecticut River above Hartford since 1867. They take a general view of the whole question of navigation of the Connecticut River, and the opinions of other parties are discussed. They are printed in the Annual Report of the Chief of Engineers for 1871, pp. 760 to 768. General Ellis's report is a part of the subreport made to accompany this one from me.

In all the subsequent surveys and control of the work, General Ellis had charge of the work in the field under my direction, and his reports give the engineering operations and plans and estimates in detail, while my reports give an account of the general direction of the work, of the disbursements, of the reasons for the course of investigation pursued, and a summary of the most important results. There are no differences between our reports on any questions. His reports were always attached to mine as subreports, and I have attached them all to this report. But in order to preserve the continuity of each, I have had him write all of his reports as one final subreport to this one from me, and mine are all united together so as to read continuously here; rewriting such parts as are necessary to make them appear properly under this arrangement, and omitting parts not now required.

In the act for rivers and harbors, approved March 3, 1871, there was appropriated "for improvement of Connecticut River above Hartford and below Holyoke, $20,000." (See Stat. at Large, vol. 16, p. 538.)

In May, 1871, advertisements for proposals with specifications as to kind of work in constructing the wing-dams, &c., between Hartford and the Enfield Falls, and the resulting proposals are published on pp. 758, 759, Annual Report of Chief of Engineers for 1871, in the table under the heading "Wing-dams." The work was awarded to the lowest bidder, C. McClellan & Son, Springfield, Mass., the price being $2.40 per cubic yard measured in the dams; and on page 760 of the report just referred to above, the contractors were reported at date of August 31, 1871, to be at work on the Scantic River Bar.

Differing views of the proper manner of improving the navigation above Hartford have now become developed. Some persons contended that Congress never designed that the Enfield Rapids should be improved, which idea the incompetency for such a work as the amount appropriated seemed to favor; while others residing above the falls, among whom was Mr. Buell, the city engineer of Springfield, Mass., held that the falls must be improved, because of the insufficiency of the

existing canal, and its onerous tolls upon vessels using it. The capacity of this canal is fully reported in General Ellis's reports, but it may be as well to repeat here that it is limited to boats of about 80 feet length, 18 feet width, and 3 feet to 4 feet draught of water.

I therefore thought it best to have a thorough survey made of the Enfield Falls, and a plan of improvement devised with a reliable estimate of cost, and it was begun as in all other cases, with the approval of the Engineer Department, during the summer. This report and estimates made from this survey were completed and submitted to Congress in February, 1872, and are printed without maps as H. Ex. Doc. No. 142, Forty-second Congress, second session, and repeated in the Annual Report of the Chief of Engineers for 1872, pp. 835 to 860, where account of the work is made continuous from the time of the preceding annual report.

Congress, by act approved June 10, 1872, appropriated "for the improvement of the Connecticut River on or above Enfield Falls, and below Holyoke, $25,000." (See Stat. at Large, vol. 17, p. 370.)

It is stated in the annual report for the year 1872, in regard to the improvements by wing-dams, made in 1871, that the work was satisfactorily done at Scantic River Bar, Strong's Island Bar, and Farmington River Bar, but was stopped by high water in the river, and nothing more could be done upon the other bars during the fiscal year ending June 30, 1872. Of the $17,000 assigned to this work, but $12,000 was expended on the dams.

To preserve the continuity of my history of the work, I will here quote my report dated January 18, 1872, after the completion of the survey and plans for improving the Enfield Falls.

General Ellis's report on the same subject comes in its regular order in the attached subreport.

IMPROVEMENT OF THE CONNECTICUT RIVER ABOVE HARTFORD.

ENGINEER OFFICE, UNITED STATES ARMY,
Newport, Rhode Island, January 18, 1872.

GENERAL: I have the honor to make the following report of operations for the improvement of the Connecticut River above Hartford, Conn., and below Holyoke, Mass., during the last half of the year 1871:

The condition of this work at the date of my last annual report, August 31, 1871, is given in your printed last annual report, pp. 756 to 768 inclusive. From this it appears that the first $20,000 appropriated, approved July 11, 1870, for the river above Hartford, had been devoted to surveying and improving the river by wing-dams between Hartford and Windsor Locks, and that the work was then in progress on Scantic Bar. (See p. 760.)

The appropriation of $20,000, approved March 3, 1871, was made specifically to embrace the Enfield Falls, and yet so small an amount would seem to indicate that with regard to an obstruction of such magnitude, nothing beyond a thorough survey and examination of the river could have been contemplated, although it was too large an amount for an ordinary survey.

Had, however, the appropriation been large enough to justify an attempt to improve the navigation at the Enfield Falls, it would nevertheless in this case have been necessary to make a survey and elaborate a plan. A survey being thus a first requisite, I directed one to be made by the assistant in charge of the Connecticut River improvements. This assistant is General Theodore G. Ellis, civil engineer, a resident of Hartford, Conn.

The survey was in progress at the time of my last annual report. (See p. 763.)

During the first part of October I made a personal examination, in company with General Ellis, of the falls and the existing canal around them on the west shore of the river. As it was important in engineering for such an expensive work to take cognizance of the capabilities of the river for navigation above and below, we extended our examination up to and including the water-power dam at Miller's Falls, about thirty-two miles above Holyoke. After a thorough personal discussion with General Ellis on

the main points to be considered, I left it with him to prepare the report, and I transmit it herewith.

It is more especially devoted to the improvement of the Enfield Falls or Rapids, but takes into the discussion of its value and importance the capacity for navigation of the river above and below it. With regard to the special part, the falls, the subject is very completely and clearly presented, and, though so concise as to be soon read through, it is exhaustive.

The Enfield Falls are entirely in the State of Connecticut. It would be perhaps sufficient for me to stop here with my report; but in order to aid those who are willing to adopt the conclusions and have not time to thoroughly consider the matter themselves, I will endeavor to give some of the leading features and conclusions arrived at, with certain military matters of incidental importance which General Ellis has apparently left to me to present.

Hartford, on the Connecticut River, is about 49 miles, by the course of the channel, from the sound, and since the improvements of the last two years can be reached by vessels of from 7½ to 8 feet draught at low tide. The tide in low stages is sensible here and amounts to about one foot.

From Hartford to the foot of the Enfield Falls the distance is 10¼ miles, and by an examination in low-water of 1870 there was in some places a depth over the bars of only about 15 inches. The bed, however, was sandy and very broad, and the volume of the water flowing was about 4,000 cubic feet a second on a gentle slope. Within this space the tide becomes insensible. After I have finished with the plan of improving the Enfield Falls, I shall recur to the question of improving this reach of river.

The Enfield Falls extend up the river 5½ miles, the head of them being 16 miles above Hartford. The bed of the river is here continuous rock, and the total fall at low-water is 31.8. The fall is not uniform, but arranged in slopes, as follows: Beginning at the head, in first 4,800 feet, falls 10.1 feet; in next 7,600 feet, falls 1.7 feet; in next 6,800 feet, falls 17.8 feet; in next 6,500 feet, falls 2.2 feet. The slope becomes more uniform as the river rises. At the highest floods the total fall is 17.6 feet. The rise from lowest to highest water at the head of the falls is about 20 feet; at the foot of the falls, 30 feet. The volume at high-water is about 162,000 cubic feet per second. General Ellis gives these quantities in more detail, but enough is here stated to show any engineer that navigation around such an obstruction can only be obtained at considerable expense.

There is practically no natural navigation at these falls, and it is enough here to say that the improvement of the natural channel so as to procure the navigation desired is impossible.

The existing canal is limited by the capacity of its locks to passing boats 77 feet long, 18 feet wide, although as a canal it is a respectable work.

From the Enfield Falls to Holyoke, a distance of 18 miles, there is now at ordinary low-water a depth for navigation said to be from 4 to 5 feet. Some improvement will, however, undoubtedly be required to realize this, and draws will have to be made in the bridges. Holyoke is 34 miles above Hartford. At Holyoke a dam has been constructed across the river, and canals for the water-power constructed on the west side of the river, which can at not very great expense be altered and adapted to the passage of boats, and it would probably become profitable to do so as soon as vessels could reach there from below. At Holyoke the lockage would have to raise vessels a height of 60 feet.

From Holyoke to the foot of Miller's Falls, a distance of 66 miles above Hartford, the river contains no serious obstructions, flows over a sandy bed, and is susceptible of ordinary river improvements, but I do not know its present capabilities. If navigation should ever be made continuous to this point, it would then be in connection with the low-grade railroad passing through the Hoosac Tunnel, now in a fair way of early completion. It does not, however, seem even remotely probable that it will pay to construct a canal around Miller's Falls; and thus we are limited in our consideration of the value of the improvement of the Enfield Falls, first, to the 34 miles of river between Hartford and Holyoke, and, proximately, to the additional 32 miles between Holyoke and Miller's Falls.

I will now proceed to the consideration of the improvements at the Enfield Falls.

General Ellis considers estimates for and discusses the advantages and disadvantages of five different plans. In general terms, he first states them as follows:

First plan.—A canal on the *west* side of the river, extending from the present dam at the head of the rapids, parallel to the old canal, down to a point just above the village of Windsor Locks; and a channel to the deep water below, to be formed by excavating in the bed of the river. Cost, $1,293,868.

Second plan.—A canal on the *east* side of the river from the dam, at the head of the rapids, to the deep water below the rapids. Cost, $869,636.

Third plan.—To dam the river at the head of King's Island, or a little below, and continue downward with a canal on the *east* side of the river to the deep water below. Cost, $961,609.

Fourth plan.—To dam the river at a point near the Enfield bridge, and lock into the river below; dam it again just below the railroad bridge near Windsor Locks and continue with a canal to the foot of the rapids. Cost, $1,222,308.

Fifth plan.—To improve the old canal so as to be navigable for boats of increased size. Cost, $1,907,565.

The discussion of these plans justifies General Ellis in rejecting the first, fourth, and fifth plans above stated, leaving him only to choose between the second and third, and a modification of the fifth, by which the old canal would be but partially improved at the present time.

After fully considering the arguments he presents, I am in favor of adopting the second plan proposed by him, provided no unexpected obstacles should be met in securing a right of way. I therefore adopt as the estimate for improving the Enfield Falls, $869,636, or, in round numbers, $870,000.

The least width of the canal is to be 150 feet on the water-line, and it will have three lift-locks to overcome the fall of 31.8 feet, whose dimensions are to be 200 feet in length, 50 feet in width, and to have 6 feet of water on the lower miter-sills.

An estimate of these proportions requires a brief statement of the causes which have led to its being made and brought to the attention of the government.

In the appropriation act approved July 11, 1870, there was an appropriation of $40,000 for improving the Connecticut River, which was made after an estimate had been submitted for improving this river below Hartford, made in accordance with section 4 of the act for improvement of rivers and harbors, approved March 2, 1867. In this section of this last-named act the present question took its origin.

The appropriation of $40,000, in 1870, was coupled with an understanding among members of Congress that $20,000 should be expended above Hartford, in which portion of the river no surveys or estimates had been directed by Congress, or made by any department of the government. After considerable delay, in 1870, in ascertaining whether this understanding by members of Congress meant that the $20,000 should be spent in Massachusetts (thus skipping over the Enfield Falls and the shoals between them and Hartford), or not, the conclusion was arrived at about the middle of December, 1870, that this fund might be expended satisfactorily to all parties by beginning at Hartford and working upward. This was evidently the only sensible conclusion.

During the winter an examination of the river throughout the State of Massachusetts and the survey of the ten and one-fourth miles between Hartford and the foot of the Enfield Falls, were made as well as could be at that season, and a plan submitted for spending the $20,000 in wing-dams between Hartford and the falls. (See pp. 756 to 76[illegible] inclusive, of your printed annual report for 1871.)

The plan thus submitted did not comprehend a thorough improvement of the river, but simply such ameliorations of the existing navigation as the amount of the appropriation seemed to contemplate, and thus facilitate the passage of such boats as were now running, and suited to the capacity of the existing canal around the Enfield Falls.

This work has been prosecuted during the past season at the Scantic River Bar, Strong's Island Bar, and Farmington River Bar, where wing-dams have been built. The work was interrupted before completion by a rise in the river, and about $5,0[illegible] of the appropriation applicable to this work remains unexpended.

We shall have to wait till after the subsidence of the next spring freshets before we can fully determine the effect which this work has produced.

By the act for improving rivers and harbors approved March 3, 1871, Congress appropriated $20,000 for improving the Connecticut River above Hartford and below Holyoke, thus specifically, by law, including the Enfield Falls, as stated in the beginning of this report. This law, however, would have allowed us to go on and expend this additional money between Hartford and the foot of the falls, as certain citizens of Windsor Locks claimed that it was intended we should; but there was an equally urgent request from citizens of Springfield, Massachusetts, claiming that there was no use of improving the river below the falls while the latter remained in their present condition.

To those acquainted with the magnitude of the improvement required, it seems impossible that Congress should have ever contemplated beginning the improvement of the Connecticut River above Hartford and below Holyoke with $20,000. But if Congress had made this appropriation without having any plans and estimates of cost before it, there seems a probability that the extent of the work to be done had not been realized, and that therefore the best thing to do was to expend only so much of the appropriation as was necessary to prepare an estimate (which would have to be done even if the appropriation were sufficient to complete the work) and submit the question again to Congress before proceeding further.

It will not do, however, to take the estimate of the amount required for the Enfield Falls ($870,000) as the sum that will make an equally good navigation all the way from Hartford to Holyoke, and I therefore return to the consideration of the improvement of the river between Hartford and the Enfield Falls. Between these points the river, in its natural state, at low-water has a depth on the bars of about 18 inches, a

the effect of the tide is generally imperceptible in the upper parts. The slope of the low-water surface is about $\frac{6}{10}$ foot per mile, the width varying from 500 to 1,500 feet, and the volume about 4,000 feet per second.

An application of the Humphreys and Abbot formula (No. 38, p. 312, Physics and Hydraulics of the Mississippi River) shows that this volume on this slope is capable of maintaining a section 508 feet wide, with a mean depth of 4 feet, and mean velocity of about 2 feet a second.

It would not be advisable to attempt to make the river at low-water narrower than this for the purpose of securing a greater depth. This would be sufficient for the comparatively short period of low-water, and a slight rain would easily make a depth of 6 feet, which is the capacity of the locks of the proposed new canal.

The bed of the river is ordinary river-sand, and easily moved by the current. The depth of the bed-rock, or hard-pan, beneath this sand, has not been ascertained, although this is an important matter in estimating the difficulty of making any permanent works in the bed of the stream.

Most of the ameliorations to low-water navigation of non-tidal rivers in this country that have been undertaken by "practical men" have been of a temporary nature, designed to afford immediate relief or at most to last but a season, or till the next rise, and with the expectation that the succeeding spring-floods would carry them away.

Were we to regard the improvement of the navigation from the point of view furnished by the low-water data above given, and suppose the river always to remain the same, the improvement of it by confining its low-water bed to a width of 400 or 500 feet would be cheap and simple.

But we must from the beginning take into account the floods of the river, and the volume to which our works for the amelioration of low-water navigation will be subjected in high-water. The high-water volume of the river is about 162,000 cubic feet per second. It rises nearly 30 feet above its low stage, overflows its ordinary banks, and spreads out over a broad valley. There are probably maximum velocities of 6 and 7 miles an hour in floods, while at low stages they cannot exceed 2 and 3 miles an hour.

The low-water slope, foot $\frac{6}{10}$ per mile, which I have given is the average between Hartford and the Enfield Falls; it is much greater at certain points at low-water, but if the river-channel is reduced uniformly to a width of 500 feet by artificial works, a uniform slope would result.

The most perfect example of a river reduced to a uniform width with which I am acquainted is the Garonne, in France, which has been thus rectified over a distance of forty-one miles.

The Connecticut is a river of somewhat greater magnitude, but presents no greater difficulties except in its ice. The ice on the Connecticut is an obstacle to our making use of the simple means of piles and wattling adopted there in the cross or tie banks between the new and old banks of the river, and we must resort almost entirely to riprap, aided by such bond as ordinary brush mingled with it will give.

It is almost obvious that any riprap walls cannot rest permanently on a sandy bed during the floods of the river. Experience has shown in every case that the amount of stone used must be sufficient to take the place of the sand as it is washed out, and sink down till it gets a firm resting-place on the bottom rock. I know of no exception to this rule in practice, and nothing else seems rational.

In the Connecticut River, between Hartford and Enfield Falls, this bed-rock cannot anywhere be less than 10 feet below the low-water surface, and I believe it is much deeper down to it.

Not having thus the data for an accurate estimate, I will present the general features of the improvement by rectifying the channel so as to secure a depth of 4 feet at low-water, from which it will appear that this will involve an expenditure between Hartford and the Enfield Falls, not less than for the improvement at the falls themselves.

Let us take one of the natural banks as our new rectified river-bank, changing from side to side as may prove best. We must riprap this bank so that its future abrasion shall not take place. Let us suppose that from the bottom of the rock-bed to the top is 27 feet, and make the covering 1 foot thick. This will require 5,280 yards per mile, at $2, $10,560. Our new bank-line must rise 3 feet above low-water, be 3 feet wide on top, slope 45° each way, and extend down not less than 13 feet, requiring about 7¾ cubic yards per foot, or 40,920 cubic yards per mile, at $2, $81,840 per mile.

Between our new bank and the old one on the side opposite where we want the channel we must put the same kind of walls normal to our new bank, in order to keep the river from going on that side. These walls should be close together on the upper side of bends where the current is strong, and less so on the lower sides of the points, but cannot be dispensed with there, because of the currents, direct and in eddies. I, however, for this estimate, average the distance for them apart at 500 feet. The sandy bed, being 1,500 feet wide, will require these to be 1,000 feet long. They must be the same in strength at least as the new bank-line just estimated for, and there will consequently be required for them 81,840 cubic yards per mile, at $2, $163,680 per mile.

The old bank against which these tie-walls abut will be subject to abrasion both from direct currents and eddies, which will work a channel-way between the tie-walls and itself unless riprapped, and this will take as much stone as for the first main bank, namely, 5,280 yards per mile, at $2, $10,560.

Summing these up, we see that each mile of rectified river will require not less than 133,320 cubic yards, at $2, $266,640; and for ten miles, $2,666,400. To this add, for superintendence, $83,600, and we have a total of $2,750,000.

It thus becomes a question whether it would not be much better to continue the canal down to Hartford, which idea I incline to, though I have no means of making an estimate of the cost of the canal.

I have estimated and planned for a number of works in different parts of the country, and I have always endeavored to present every subject in as favorable light as it would bear, and not to crush a needed work with an exorbitant estimate; but, at the same time, I have endeavored not to commit the government to an undertaking without counting the cost.

The foregoing must put the improvement of the Connecticut River in a different light from that in which it has been heretofore contemplated.

If Congress intends to continue such ameliorations of the existing navigation as small appropriations of $20,000 annually will admit of, we must give up the idea of making any new improvements at the Enfield Falls. We must satisfy ourselves with aiding the passage of the river above and below the falls by such vessels as can now pass through the existing canal, and these vessels must continue to pay toll to the canal company. I advise this latter course to be continued at any rate, and that if the grand improvement is contemplated which shall let small Sound-going vessels, small gun and torpedo boats, ascend the river as far as Holyoke, that additional surveys be ordered to further develop the plan as a whole. Of the original appropriation of $20,000 for improvement above Hartford and below Holyoke, we have expended now about $5,500, so that there remains $14,500 that can be applied to additional surveys. If it is to be expended in improvements, I recommend that it be all employed on the river below the Enfield Falls, the first appropriation of $20,000 for this part being about exhausted.

Whether the object to be accomplished, in a national point of view, is commensurate with the expense, is a question of statesmanship. How far the improvement of the Connecticut River, so as to allow small gunboats and torpedo-vessels to patrol it would contribute to natural defense, can hardly be estimated until this valley becomes the theater of actual war. But were the New England States a separate nation, they would undoubtedly improve it for this purpose; and as this is a portion of our country that a foreign power would most probably seek to isolate from the rest, it would seem advisable to make it capable of independent defense.

At Springfield there is an important national armory, and at Hartford and other places private manufactories of war material national in character and importance, though not the property of the government.

Yours, respectfully,

G. K. WARREN,
Major of Engineers and Brevet Major-General, U. S. A.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

Congress, by act approved March 3, 1873, appropriated "For improvement of Connecticut River above Hartford and below Enfield Falls, $20,000."

The Annual Report of the Chief of Engineers for 1873 brings the account of the work up to August 30 of that year. (See pages 90 and 91, and Appendixes W 18 and 19, pages 1003 to 1011.)

The appropriation made June 10, 1872, of $25,000 for the part on and above Enfield Falls and below Holyoke seemed to call for a survey up to this last point, and it was begun in 1872, but only partially made, on account of almost continuous high water. This survey was continued in 1873. The following is quoted from the annual report for 1873, pages 1004–1005:

In 1872 an attempt was made to resurvey the portion of the river between Hartford and the Enfield Falls to ascertain the condition and effect of the wing-dams built in 1871, but high water prevented all operations to this end, and no improvement of the river in this part was undertaken. Some previous considerations had shown that, for a thorough improvement between Hartford and the Enfield Falls, in connection with a thorough improvement at the latter place, it might be cheaper and more reliable to

construct a canal between the two places instead of attempting to improve the natural channel. As, therefore, all operations in natural channel were stopped by high water, a survey was made to ascertain the best location and cost of a canal between these two points. This survey has been made by General Theodore G. Ellis, civil engineer, and the report, with the drawings, plans, and estimates, is now transmitted.

By reference to the report of the improvement around the Enfield Rapids in the last annual report (referred to above), it will be seen that the depth of water on the miter-sills of that proposed canal is 6 feet, that depth being all that it was thought could be secured by any improvement of the river-channel up to Warehouse Point, the lower terminus of this canal. But by extending the canal down to the mouth of the Hockanum River, just below Hartford, a point on the river is reached where a draught of 8 feet at low-water could always be relied upon. The project of beginning the canal as low down as this latter point justified an increase of capacity of the whole projected canal, which has accordingly been made. A further modification was necessary in the first project in regard to locking down into the river at its lower extremity. These locks would be dispensed with, and the first line abandoned back to a point suitable for the continuation of the canal down to the mouth of the Hockanum.

All of these things, as to cost, &c., have been taken into account in General Ellis's report. The canal from the head of the Enfield Rapids down to the mouth of the Hockanum River, on the east side of the valley, is to be 150 feet wide and 10 feet deep, with locks 200 feet long, 50 feet wide, and 8 feet depth on the miter-sills. There are to be three locks, all at the lower end of a lift respectively 14½, 11½, and 11½, or 37½ feet lift in all. The whole length of the canal, from the mouth of the Hockanum to the Enfield dam, at the head of the rapids, is 16.8 miles. This canal is designed solely for the purposes of navigation, and not to furnish water-power. Its cost is estimated at $2,306,345. It is too soon yet to fully consider this project, the survey above the rapids and the resurvey between them and Hartford not having yet been completed. These have, however, been in progress during the present season under most favorable conditions of low water, and we may be able to finally report upon the river this winter.

The low water has also enabled us to examine the effect of the wing-dams built by us in 1871 between Hartford and the Enfield Rapids. These have been found to produce favorable results, and have increased the low-water depth from 1½ and 2 feet to 2½ and 3 feet.

At points where the dams had not been built the former shoals remained, and were so bad at Barber's Landing Bar that we employed a dredge by the day in the summer of 1873 to cut a channel through to afford temporary relief.

The continuation of the project of building wing-dams between Hartford and the Enfield Rapids seems, therefore, warranted to facilitate present navigation, although they should not meet ultimate requirements. The high water early in the season prevented our gaining a knowledge of this result in time to work to advantage this season. In view of the funds already on hand, I have made no estimate for further appropriations for this part of the river for the fiscal year ending June 30, 1875.

The detailed report of General Ellis of the survey for a canal along the river between Hartford and the Enfield Falls is given in its chronological order in the subreport forming the appendix to the present report.

The surveys and examinations on the Connecticut River above Hartford are next reported upon up to July 1, 1874, in Annual Report of the Chief Engineers for 1874, page 101, Part I, and pages 249 to 257, Part II. From pages 249 and 250, Part II, the following is taken:

During the past fiscal year work in this portion was mainly confined to completing a thorough survey of it. This has now been done, and the maps finished on a scale of 400 feet to the inch, forming six sheets. The maps and a diagram of borings made, with a preliminary report of Assistant Engineer General Theo. G. Ellis, who conducted the survey, are presented herewith. Some few other observations in connection with ganging the low-water volume of the river remain to be done, and then the final report, giving a review of the whole matter, will be made.

The last annual report gave a clear general idea of what has been done up to that date, and it need not be repeated here.

During the season of 1873 a channel 2½ feet deep was dredged through Barber's Landing Bar. This was the only improvement then needed.

The surveys last year showed that the wing-dams between Hartford and the Enfield Falls, as far as built, had been very beneficial, and that this means of improvement would probably be adequate to present requirements of navigation, or until there is a great improvement made at the Enfield Falls. An expenditure of not less than

$870,000 will be required for the improvement of these falls alone. (See Annual Report for 1872.) Until the improvement of the river is undertaken with a view to carrying it to the extent which this contemplates, and until the ruling depth to be secured is fixed, the kind of improvement to be adopted at different localities cannot be decided. With the present small appropriations only alleviations of obstructions to existing navigation can be attempted, and the requirements of this are determined by the existing canal and locks.

Our survey shows no place between the Enfield Falls and Holyoke where the present class of vessels find any obstruction or need any greater facilities than they now have.

Of the appropriation of $25,000, appropriated June 10, 1872, for improvement "on or above Enfield Falls and below Holyoke," we have expended about half in surveys and measurements. We find, as before said, no place where the remainder can be used above the falls, and it is inadequate to doing anything upon them.

Of the former appropriations for improvement above Hartford and below Holyoke there is on hand $21,772.31, which, by the words of the act, is available to improve the river between Hartford and Enfield Falls. It is proposed to expend the money in this portion of the river by building wing-dams and dredging, as the formation of shoals may require.

The improvement of the Connecticut below Hartford is more important to the whole Connecticut River Valley than is the improvement above, and for the present it would be better to confine the expenditures to the lower part of the river.

The appropriation of $25,000, made by act approved June 10, 1872, is applicable to the river only "on or above Enfield Falls and below Holyoke"; a part of the river where there is sufficient depth of water for the class of vessels navigating it. What remains on hand of this appropriation is not available for any part of the river where it is needed. In making up the "financial statements" this appropriation is given in a separate statement.

FINANCIAL STATEMENT.

Connecticut River on and from Enfield Falls to Holyoke, Mass.

Balance in Treasury of United States July 1, 1873	$25,000 00
Amount expended during the fiscal year ending June 30, 1874	12,391 45
Amount available July 1, 1874	12,608 55

Connecticut River above Hartford and below Holyoke, Mass.

Balance in Treasury of United States July 1, 1873	$25,000 00
Amount in hands of officer and subject to his check	1,606 65
Amount expended during the fiscal year ending June 30, 1874	4,834 34
Amount available July 1, 1874	21,772 31

The maps referred to above have never been published. They are sent with this report for publication. General Ellis's report is included, like his others, in its proper place in the subreport forming an appendix.

In the Annual Report of the Chief of Engineers for 1875, page 110, Part I, and pages 300 to 369, Part II, the main portion of the final results of the hydrographic and hydraulic investigations are given. These possess an interest to many other river improvements, and are of much value, independent of the special river investigated. I will quote here the part of the annual report made by myself, General Ellis's report, like the others, being given herewith in the appendix among his other reports, together with the illustrating diagrams (most of them not heretofore printed).

CONNECTICUT RIVER ABOVE HARTFORD, CONNECTICUT, AND BELOW HOLYOKE, MASSACHUSETTS.

During the fiscal year the high stage of the river has rendered any work of improvement unnecessary, and no such work was done. The surveys of this portion of the river and investigations connected with it were prosecuted to completion.

The surveys were begun in December, 1870, by making a general reconnaissance of the river between Holyoke and Hartford, with special surveys at certain shoals between the Enfield Rapids and Hartford. (See Annual Report for 1871, pp. 762–768.) In 1871 a thorough survey was made of Enfield Rapids, and estimates of cost of various plans of improvement were submitted. (See Annual Report for 1872, pp.

5–860.) In 1872 a survey was begun at Holyoke, and a thorough survey was made d estimates prepared for constructing a canal from Enfield Rapids to Hartford, so at we might compare it with the project for improving the natural channel between ose two points. (See Annual Report for 1873, pp. 1003–1011.)

In 1873 the survey was completed between Hartford and Holyoke, and fully reported , with the exception of the hydraulic measurements and other data that required re time to work up. (See Annual Report for 1874, Part II, pp. 249–257.)

The present report concludes these surveys and investigations. The operations have en conducted under my direction by General Theodore G. Ellis, assistant engineer, d his last report is here appended. This report relates mainly to the measurements obtain the volume of discharge of the Connecticut River at all stages. For this rpose the river near Thompsonville, about 1¼ miles above Enfield Rapids, was se- ted. This place, from its position with regard to the rapids, was favorable for a ar uniformity of discharge at the same stages of the river whether rising or falling. perience in gauging rivers elsewhere had shown that the volumes discharged at the ne reading of the gauge were materially greater in rising than in falling stages. e results confirmed the anticipation, but in one or two instances it turned out that e ordinary experience was reversed, and the greater discharges occurred on falling ages.

The measurement of the volume required accurate determinations of the velocity of e current in all parts of the cross-section of the stream, and inasmuch as there had en recently some questions raised about the proper or best method of measuring elocities, whether by current-meters or floats, and other questions about the law of hange of velocities in the vertical plane from the surface to the bottom, it was decided o try both floats and meters, each kind constructed in the most careful manner. The urface and subsurface float employed by General Ellis is admirably constructed so as o secure reliable indications. Two excellent current-meters were used, one with crew-blades and registering-wheels attached; another consisting of four cups at the ends of two bars at right angles with each other, so that the water caused it to turn ordinarily on a vertical axis, but which worked equally well at any angle with the vertical. This latter registered by means of a galvanic battery, the armature of which was connected by a lever with the escapement of a train of clock-work provided with dials recording the breaks in the circuit, which were made to take place at each revo- lution of the meter. This meter was specially adapted to slow velocities.

All the apparatus is described with great minuteness and precision in General Ellis's report, as well as the manner of conducting the operations and rating the meters.

The total number of velocity-observations at Thompsonville was 1,434. They were taken at every foot of depth and at intervals of about 100 feet apart across the river; several contiguous sections being thus measured. These observations are given in detail in his report. Besides using them to obtain the volume of discharge, they are grouped in various ways to ascertain the form of the vertical curve, and to compare the different methods with each other. Tables of these comparisons are given in his report.

One of the most important conclusions reached by this is, that both the floats and meters give concordant results, showing that each is reliable when carefully and intelligently employed, and that each method has certain advantages over the other under peculiar circumstances. There seems, therefore, no reason to discredit the results of either method, when there is evidence that it has been properly used.

Another most important conclusion from these results (at least to those who have felt doubts) is the full confirmation they afford to the parabolic form of the curve of subsurface velocities, as shown in the Physics and Hydraulics of the Mississippi, by Humphreys and Abbot. This is a result free from any bias on the part of the observer. General Ellis and his assistants (civil engineers) prepared the apparatus, conducted the operations, and worked out the results without any dictation from any one. Whatever consultations or comparisons have been made, General Ellis's course of action has been left free. An attentive perusal and examination of his report will be necessary to enable one to do justice to this subject. I will not, therefore, attempt an abstract of it, but will give here but one diagram showing how well the results of observations conform to the curve of the parabola given by the Humphreys and Abbot formula, with the parameter as derived from the Mississippi observations. This diagram is No. 9 of Ellis's report.

The points marked thus ⊙ are the grand means of all the subsurface velocity-measurements, both with floats and meters combined, at tenths of the depths in the sections observed, so as to bring all together. The full curve drawn is the parabola in the position required by the Humphreys and Abbot formula. The maximum discrepancy is only seven-hundredths foot per second. The position of the axis is taken at one-tenth of the depth, which is nearly that of the maximum observed velocity. A little nearer accordance, perhaps, may be gained by a slight change in the value of the parameter of the parabola in the equation.*

*The parabola most nearly conforming to the mean of the Connecticut River observations is shown by the dotted line in the diagram.

The test of the Humphreys and Abbot middepth velocity theory, *i. e.*, the constant ratio of middepth velocity to mean, is shown by the following:

$\frac{V\ m}{\sqrt{i\ D}}$ = for meter observations on low velocities 0.933
= for float observations on low velocities 0.918
= for meter observations on high velocities 0.939
= for float observations on high velocities 0.961
= by Humphreys and Abbot's formula ..... .955

This appears to be a satisfactory confirmation.

Observations were made upon the slopes, but time has not sufficed for us to make any comparison with formula in which this factor enters.

In General Ellis's report is a calculation of the entire volume of water that flowed past Hartford in the years 1871, '72, '73, and '74. If meteorological observations furnish the means of calculating the precipitation in the area drained, an interesting ratio of downfall to drainage may be obtained.

IMPROVEMENT.

In regard to the improvement of the navigation of this portion of this river, I should say that nothing of any importance can be done until there is an adequate canal around the rapids, which the present appropriations are too small even to make a beginning with.

Between Hartford and Enfield Rapids we are engaged on wing-dams to increase the depth a little at the worst bars, so as to float the boats that can pass the existing canal. This canal is owned by a water-power company, and is too small for extensive transportation. The river between Enfield Rapids and Holyoke is now in as good condition as is desired by any vessel that can reach it.

In 1872 an appropriation of $25,000 was made exclusively for this part of the river, without any plan of improvement having been made.

With this we have carefully surveyed this portion of the river without finding any place where it can be expended for any good purpose. There is a balance remaining on hand of $10,702.92, which might be used for publishing the maps. If this cannot be done, it should be transferred to the mouth of the river or be covered into the Treasury.

The money on hand available for the part of the river between Enfield Rapids and Hartford, $18,938.69, is all that is at present needed, and no further appropriation for the river above Hartford is asked for.

Hartford is in the Middletown collection-district.

FINANCIAL STATEMENT.

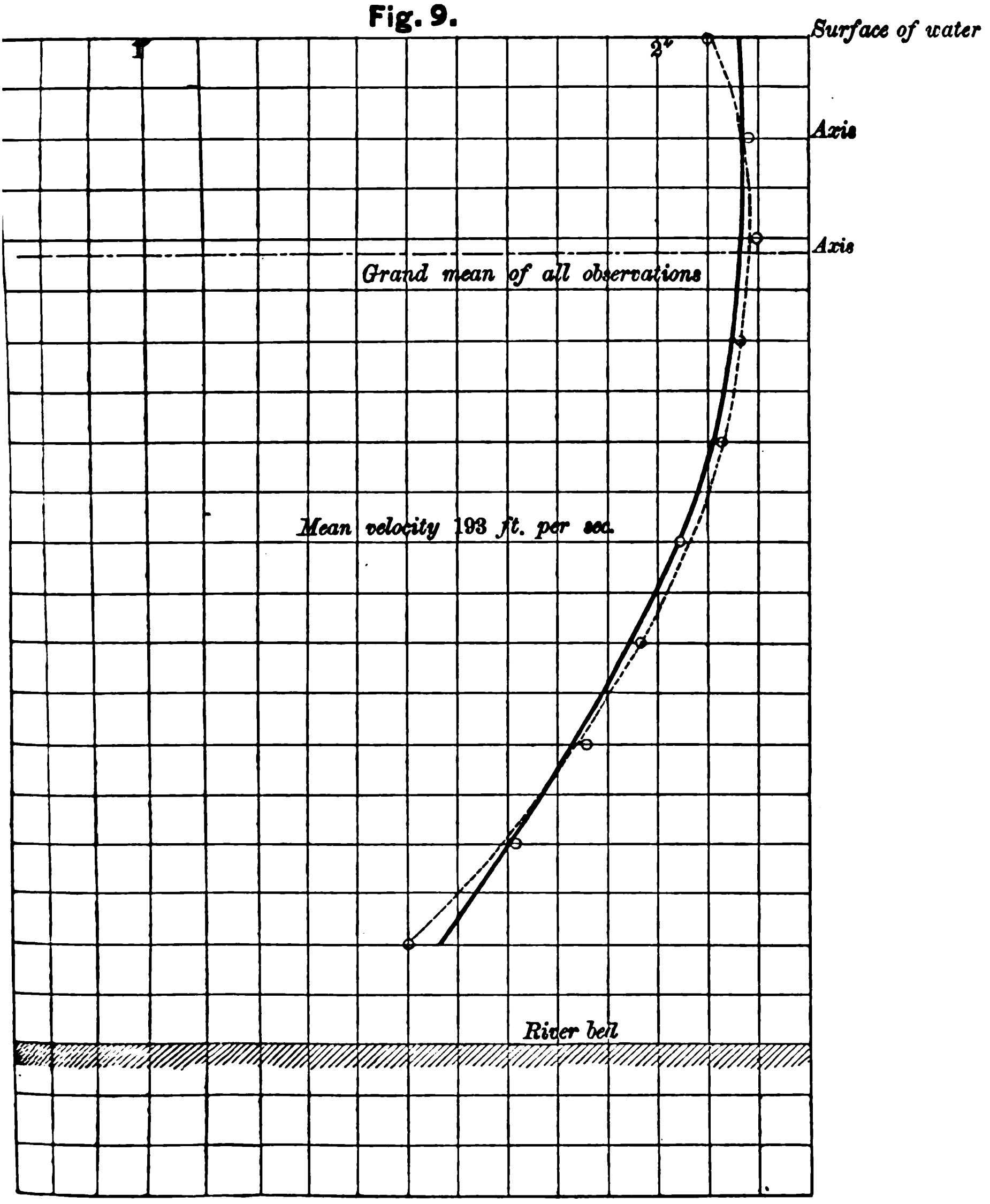
Connecticut River above Hartford and below Holyoke.

Balance in Treasury of United States July 1, 1874	$12,000 00
Amount in hands of officer and subject to his check, July 1, 1874	9,772 36
Amount expended during the fiscal year ending June 30, 1875	2,893 62
Amount available July 1, 1875	18,878 74

Connecticut River from Enfield Falls to Holyoke.

Balance in Treasury of United States July 1, 1874	$10,000 00
Amount in hands of officer and subject to his check, July 1, 1874	2,608 55
Amount expended during the fiscal year ending June 30, 1875	1,905 63
Amount available July 1, 1875	10,702 92

Fig. 9.


1'
2'
Surface of water
Axis
Axis
Grand mean of all observations
Mean velocity 193 ft. per sec.
River bed

It must be added to the above, taken from the annual report for 1875, that General Ellis's report contains a very valuable contribution to the question of the ascent of the tidal waves along an estuary like the Connecticut, which subject properly came in this field of investigation, because the tides are sometimes felt above Hartford.

The statement with regard to the Connecticut River above Hartford is given in the Annual Report of the Chief of Engineers for 1876, page 51, and pages 213 to 217 of Part I. From this the followiug is extracted:

CONNECTICUT RIVER ABOVE HARTFORD, CONN., AND BELOW HOLYOKE, MASS.

During the fiscal year ending June 30, 1876, the condition of the river has been such as to require no expenditure for improvements. The material obtained from the surveys and measurements in former years has been worked up ready for publication, and all the maps and diagrams prepared for photolithographing. During the progress of the work separate portions of the river and surveys were reported upon by themselves, and these reports have been published in the preceding annual reports. We have, however, combined them all in one report, which it is now desirable to publish by itself, accompanied by the maps and diagrams that generally have not been published.

Some careful measurements on the resistance of cords and floats to currents of water having different velocities (included in this combined report) have not yet been published, and they are therefore given here as an appendix. As there appears little likelihood that the money appropriated for this river above Enfield Falls and below Holyoke can be used in any desirable improvement, I respectfully suggest that the money be partly used in publishing these maps and full report. It will be of much local value as affording exact information of the river and valley, and in the results of its measurements a contribution to river hydraulics and of general interest.

If any shoals should give trouble to the vessels now navigating between Hartford and Enfield Falls this year, the funds on hand are believed to be ample to provide for removing them.

Connecticut River is in the Middletown collection-district. Middletown is the nearest port of entry. The amount of revenue collected there during the fiscal year ending June 30, 1876, was $19,956.14.

MONEY STATEMENT.

Above Hartford and below Enfield Falls.

Amount available July 1, 1875	$12,272 04
Amount available July 1, 1876	12,272 04

Above Enfield Falls, Conn., and below Holyoke, Mass.

Amount available July 1, 1875	$10,702 92
Amount available July 1, 1876	10,702 92

Above Hartford, Conn., and below Holyoke, Mass.

Amount available July 1, 1875	$6,606 65
Amount expended during the fiscal year ending June 30, 1876	2,774 82
Amount available July 1, 1876	3,831 83

The subreport of General Ellis appears in the appendix. The measurements as to the resistance of cords, &c., are a valuable contribution.

The Annual Report of the Chief of Engineers for 1877 gives the last report preceding the present one made on the river above Hartford. (See page 45 and pages 206–7 of Part I.) From this the following is extracted:

CONNECTICUT RIVER ABOVE HARTFORD, CONN., AND BELOW HOLYOKE, MASS.

The condition of the river has been such as to require no expenditure for improvements during the fiscal year ending June 30, 1877. If any shoals or other obstructions

should give trouble to such vessels as can pass the Enfield Falls during the present year, the available funds will be used for their removal, and they are deemed sufficient to meet any such contingency. A thorough improvement of the Enfield Falls, as already reported, is a necessary preliminary to any increase in the navigable capacity of this river above Hartford. This alone will cost from $800,000 to $900,000.

To make a thorough improvement of the river between Hartford and Enfield Falls will cost between $2,000,000 and $3,000,000.

MONEY HERETOFORE APPROPRIATED FOR THIS IMPROVEMENT.

One-half of amount appropriated for Connecticut River, June 11, 1870	$20,000
Above Hartford and below Holyoke, March 3, 1871	20,000
On and above Enfield Falls and below Holyoke, June 10, 1872	25,000
Above Hartford and below Enfield Falls, March 3, 1873	20,000
Total	85,000

Of these, the first was expended upon wing-dams; the second has been partly expended upon surveys and dredging; the third has been partly expended upon surveys and dredging; the fourth has been partly expended upon surveys.

The amounts appropriated have been wholly inadequate to making any thorough river improvement, and so there was means for making thorough surveys. As far as needed, these surveys have now been made.

In my last annual report upon this work, I stated that it was desirable to have the reports made upon surveys of this part of the river during the progress of the improvement published in a combined report, with the maps and diagrams. It does not seem probable that the money appropriated for this river above Enfield Falls and below Holyoke will be needed for improvement, and I suggest that so much as is necessary be used in publishing these maps and a full report. The maps have been already prepared for photolithographing.

After this is done, I recommend that all the money appropriated for the river above Hartford (reserving $5,000 for the shoals between Hartford and Enfield Falls) be, by law, transferred to the improvement of the bar at the mouth of the river.

Connecticut River is in the Middletown collection-district. Middletown is the nearest port of entry. The amount of revenue collected there during the fiscal year ending June 30, 1876, was $19,956.14.

MONEY STATEMENT.

Above Hartford, Conn., and below Holyoke, Mass.

Act of March 3, 1871:	
July 1, 1876, amount available	$3,831 83
July 1, 1877, amount expended during fiscal year	541 40
July 1, 1877, amount available	3,290 43

On and above Enfield Falls, Conn., and below Holyoke, Mass.

Act of June 10, 1872:	
July 1, 1876, amount available	$10,702 92
July 1, 1877, amount available	10,702 92

Above Hartford and below Enfield Falls, Conn.

Act of March 3, 1873:	
July 1, 1876, amount available	$12,272 04
July 1, 1877, amount available	12,272 04
Total available above Hartford July 1, 1877	26,265 39

In producing consecutively the several annual reports, I have shown all the successive stages, and each time produced a summary of what had preceded it. This last annual report is itself probably a sufficient summary of what has been done to one who has followed the report throughout, and it is only by such examination, step by step, that the whole matter can be understood.

In the appendix embracing the several reports of General Ellis, all the diagrams are described which it is desired to publish, and they accom-

pany this report. Those diagrams showing volumes of discharge have been brought down to December 31, 1877.

There remains but to say that initial steps have been taken this spring to continue work upon wing-dams between Hartford and Enfield Falls, should a low stage of water make it necessary, and no additional appropriations are needed for this purpose.

For the future it remains for the people of the Connecticut Valley to determine what kind of an improvement they will undertake, and take measures to secure the money. Engineering skill and science have exhausted the field, and plans for almost any alternative plan of improvement the people may select are already prepared.

It seems therefore that the next reasonable step in the direction of progress is to publish the report in full, with its diagrams, so that they may have an opportunity to see what the conditions are, and choose the best course.

Very respectfully, your obedient servant,

G. K. WARREN,
Major of Engineers, Bvt. Maj. Gen., U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

REPORT OF GENERAL THEO. G. ELLIS, ASSISTANT ENGINEER.

GENERAL CHARACTER OF THE RIVER.

The Connecticut River rises in the extreme northern part of the State of New Hampshire, near the Canada border, and flows southwardly between the States of Vermont and New Hampshire and across the States of Massachusetts and Connecticut to Long Island Sound.

North of the Massachusetts line the water-shed is narrow and precipitous, and the tributaries are small, partaking of the character of mountain torrents, the principal streams entering the Connecticut in New Hampshire being the Upper and Lower Ammonoosuc and the Ashuelot Rivers, and in Vermont the Passumpsic, White, and West Rivers.

In Massachusetts the Chicopee and Miller's Rivers flow into it from the east, and the Deerfield and Westfield Rivers from the west. The principal tributary in the State of Connecticut is the Tunxis, or Farmington River. This rises on the easterly slope of the Green Mountains, in, Massachusetts, and flows southeasterly to Farmington, Conn., where it makes an abrupt bend to the north, and passes through the range called Talcott's Mountains, when it again turns southeasterly, and enters the Connecticut opposite the town of East Windsor. Two small streams enter the Connecticut at Hartford, the Hockanum on the east and Little River on the west. Below Hartford the streams are small, and except during rains furnish but little water to the river.

From its source to the Massachusetts State line the banks of the Connecticut are generally of a permanent character. Through the State of Massachusetts the river passes mostly through an alluvial formation, though in some places the bed is formed of hard and permanent materials. From the town of Northampton to Hartford the river flows through alluvial meadows overflowed in high freshets. Through Massachusetts and Connecticut the banks are not generally wooded, but occasional patches of wood and many single trees stand upon them.

The Connecticut River is navigable to Hartford for schooners and large steamboats and by means of the Enfield Canal for smaller craft as far as Holyoke.

Below Hartford, as far as Rocky Hill, a distance of about nine miles, the river runs through meadows, and the banks are generally a clayey loam upon the outsides of the bends, while upon the opposite sides are low sand beaches, deposited during freshets. The banks upon the outside of the curves are washing away rapidly.

From Rocky Hill to the narrows below Middletown the banks are generally permanent and not liable to wash. Through the "straits," for a distance of about a mile, the banks are high and rocky and the channel is deep and narrow.

From this point to the mouth of the river the banks suffer but little abrasion from the current, and are generally hilly, sloping downward to the river, and in many places rocky.

The bed of the stream is mostly hard sand and gravel, with some mixture of mud in the lower part near the mouth. At the mouth, where the stream enters Long Island Sound, there is a bar such as is usually formed by rivers which transport sediment and flow through an alluvial region.

FRESHETS.

The Connecticut River is subject to freshets of considerable height, which occur principally in the spring, when the volume is swollen by the melting snow, although occasional floods have occurred in every month of the year except July and September. The highest freshets generally take place in the spring. There was one remarkable exception, however, in August, 1856, when the water at Hartford rose to a height of 23 feet 4 inches above low-water mark. This was caused by unusually heavy rains which occurred at that time.

The freshet of May, 1854, is the highest known below Holyoke. This was 29 feet and 10 inches above the low-water mark of the Hartford gauge. The freshet of April, 1862, was the highest known on Holyoke dam, and was probably the highest in the river above that point. At Hartford it was 1 foot and 2 inches lower than that of 1854.

Previous to these two freshets the flood of 1801 was the highest on record, and formed the basis of most of the points of reference along the river previous to 1854. The low-water mark was 27 feet and 6 inches below this high-water at Hartford, and the present city base is intended to be 30 feet below it. The same low-water mark is retained at the present time, although the water has been supposed once to have fallen below this zero. In 1867 there was, at the northeast corner of Chapin's wharf, upon a large, firm pile, four spikes, put in by different persons at the lowest stages of the water in different years. The lowest one was driven by Mr. E. B. Farnham, of Hartford, at the extreme low-water of August, 1858, and was .11 of a foot lower than the level of the zero of the gauge at the toll-bridge. This is the lowest water known. The next spike was .12 of a foot higher, corresponding to about the zero of the gauge, and was said to have been driven by Mr. Hempstead, a former surveyor of the Union Company, which built some wing-dams upon the river below Hartford. The other two spikes were higher up. One of them was driven by Mr. P. B. Goodsell, a surveyor of the Union Company, in 1833, and the other by some other person not known.

SURVEYS OF 1871.

The first reconnaissance of the Connecticut River between Hartford and Holyoke, with a view to improving the navigation, was made in January and February, 1871, and the following report was then submitted.

The points referred to upon the maps and charts transmitted with this report can be found upon the reduced maps of the river herewith appended, Plates I, II, and III.

HARTFORD, CONN., *March* 4, 1871.

GENERAL: In conformity with your letter of December 20, 1870, regarding work to be done on the Connecticut River above Hartford, I beg leave to submit the following report:

A general reconnaissance of the river above Hartford shows that it has been in former times navigable for boats of light draught at certain stages of the water, even as far up as the States of Vermont and New Hampshire. This was accomplished by means of canals around the Enfield Falls and Rapids, extending from 11 to 16 miles above Hartford; at South Hadley Falls, about 34 miles; and at Miller's Falls, near Greenfield, Mass., about 66 miles, by the river, above Hartford. Since the construction of the railways in the Connecticut Valley, however, the canals above Springfield have fallen into disuse, and there is now no navigation above the village of Holyoke, Mass.

At this place the bed of the canal still remains, being mostly excavated in the solid rock; but the locks and gates have long since disappeared, leaving a succession of falls in the bed of the canal.

The Holyoke Water-Power Company, in their new dam recently completed, have constructed a lock of about 15 feet width at the east end of the dam where the canal now commences, so that it is possible to repair it for use, although the great expense of the work would not be at all warranted by the amount of trade that would be likely to pass through it.

A paper-mill is now built directly over the bed of the canal, but the archway could be raised sufficiently for the passage of boats. This canal is at present used only as a tail-race for the mills along its border.

Holyoke is now, and likely to continue for many years, the head of all navigation on the Connecticut River.

Between Holyoke and Springfield, a distance of about ten miles, it is said that there are some bad places; but that boats drawing 4 or 5 feet can pass at an ordinary low stage of the water.

A line of soundings run from Springfield to Holyoke does not show anything less than 5 feet in depth at low water in the channel.

On this part of the river there are two bridges, neither of which has a draw; but they are sufficiently high to allow boats without masts to pass under them.

From Springfield to Enfield Falls, a distance of about 8 miles, the river is comparatively good, being mostly over 8 or 9 feet deep, with but one bar of any importance, at Long Meadow Flats. On this there is about 5 feet at low water, as sounded through the ice the past winter.

A line of soundings has been run from the head of the Windsor Locks Canal to Springfield, following as nearly as possible the line of the channel, and this was the worst place found.

Immediately at the head of the canal there is a shoal of small extent, caused by the current setting into the entrance, which has not been surveyed, as it is probable that when the channel below is improved the canal company will take care of that as well as the bed of the canal.

At Springfield there are two bridges, neither of which has draws, and there are no others down to the Enfield dam and the head of the canal.

The Windsor Locks Canal, reaching from above the dam around Enfield Falls and the rapids below a distance of 5 miles, is mostly used at the present time as a water-power for manufacturing purposes at the village of Windsor Locks.

The bed of the canal at the surface of the water is from 50 to 100 feet wide, and the water is from 5 to 12 feet in depth. There is an entrance lock at the upper end 77½ feet long and 20 feet wide, and at the lower end there are three locks, each 77 feet long and 18½ feet wide. All of these locks are in poor repair. The canal is somwhat filled in by washing from the banks, and is much troubled by a long eel-grass growing up from the bottom. It can, however, be put in passable condition with little expense. This will probably be done by the company when the channel is improved below. During eight weeks last summer no boats were able to get up as far as the canal on account of the low stage of the river.

Although there is a fall of about 25 feet in the 5 miles of river alongside the canal, it is navigable at certain stages of the water, an opening being left in the middle of the Enfield dam to allow boats to pass.

By the way of the river, boats are obliged to pass under the highway bridge at Enfield, and the bridge of the New Haven, Hartford and Springfield Railway, which also have spans over the canal. These bridges have no draws, although the charter of the railroad company requires them to have one. The railroad bridge has a "draw-span," where it was intended that a draw should be placed, but it is near the west end of the bridge, and not over the channel, which runs near the middle of the river. Between the lower outlet of the Windsor Locks Canal and Hartford are, at present, the worst places in the navigable portion of the river. By measurements taken while descending the river in a small boat during the lowest water last summer, the depth of water on the bars in the course of the channel, indicated by the captain of a boat navigating this portion of the river who accompanied me, was as follows: At Barber's Landing, 1 foot; at Farmington, or Tunxis River, 1.5 feet; at Strong's Island, 1.3 feet; at Scantic River, 1.2 feet. The deepest places on the bars were probably not found.

SURVEYS.

In view of the amount of the appropriation for this part of the Connecticut River, it was thought best not to make any extended or expensive surveys, but to give especial attention to that part of the channel which presented the greatest obstacles, and which seemed to be in the most immediate need of improvement. The worst part of the river being between Hartford and Windsor Locks, it seemed advisable to commence with the improvements at Hartford, and improve the channel upward as far as the appropriation would allow; especially as the lower part must be passed to reach the upper, and while the obstructions existed below there was no navigation at all on the better portion of the river above.

It has also been deemed preferable to make a moderate improvment in all the worst places below the canal, so as to permit the passage of boats of light draught at all stages of the water, rather than to expend too much upon any one place; so that whatever improvements are made with the present appropriation will benefit the whole river above.

In conformity with these views, surveys have been made on the lower part of the river during the past winter, since January 1, to determine the position of the bars and the best method of improving the channel.

On the maps herewith presented the soundings are reduced to a uniformly-inclined surface between the low-water mark at Hartford, which is assumed at the zero of the gauge-board at the toll-bridge, and what is supposed to be the low-water mark at the mouth of the Scantic River near the village of East Windsor Hill.

Bench-marks were established at intervals, and all soundings referred to gauge-stakes set from the bench-marks.

These benches were carefully leveled over between Scantic River and the gauge-board at Hartford. The height of the water at each end of the line was taken every ten minutes on three different days, to get the average slope of the water surface and to eliminate the effect of fluctuations of the river, which, fortunately, during the observations, were very small. The average of the observations for a mean height of water of 2.64 feet at Hartford, varying between 2.41 and 2.97 feet, gave the slope of the river surface between the two points at 3.10 feet, with a probable error of $\pm$.06 foot. The total distance by the river between the points observed is 38,300 feet.

The slope of the surface at extreme low-water has been assumed, however, at 3.83 feet between the above-named points, or 0.1 of a foot in 1,000 feet, as extreme low-water at Hartford is caused by uncommonly low tides, which materially increase the slope of the river at such times, there being little or no tide at the mouth of the Scantic, and sometimes a foot and a half at Hartford. It is believed that the plane assumed is as near as possible to extreme low-water mark over the portion of the river where soundings were taken.

The presence of the ice on the surface of the water during the time of the surveys, by its retarding influence upon the upper stratum of water, has the effect probably of deepening the channel over the worst places on the bars by increasing the current on the bottom, but the stage of the river having been at about the level of ordinary low-water during the progress of the surveys, the change has not probably been material.

CHARACTER OF THE BOTTOM AND BANKS.

The bottom of the river upon the parts where soundings were taken is coarse and fine sand, with a mixture of mud in the deeper places.

Upon the crests of the bars it is a fine clear material, which moves easily, and the grains of which roll over and over each other with the current, forming small waves on the surface of the bottom, until the grains reach the top or crest of the bar, when they fall down the steeply-inclined slope of the lower side of the ridge.

This is the operation at low-water: at high-water the bars are probably carried away, to be reformed again as the river falls to its low level.

The character of the bars above Hartford differs materially from that of those below. The latter lie square across the river, with the deepest water above and below them in almost the same line, and crossing the deepest point of the bar. Above Hartford the bars are less compact, and their formation is more up and down diagonally across the river, with the deep water extending into each acute angle formed with the banks.

The channel runs down on one side, between the bar and shore, until the greater part of the water is wasted over the shoal, and forms another channel on the other side, which again has deep water, and usually continues for some distance down stream.

The general principle adopted for improving the navigation over these bars is not so much to direct the water flowing in the channel, as to cut off the wastage over the upper part of the shoal by suitable wing-dams, so as to force more water into the proper and natural channel, to enable it to scour out deeper by the increased abrasion of the water on the bottom.

The character of the banks could not well be observed during the progress of the survey, owing to the great amount of snow; but, from previous observation, they are known to be washing away on the outside of the bend, for about 2 miles above Hartford, and to be tolerably permanent above that point.

HIGLEY'S POINT BAR.

The first place above Hartford needing immediate improvement is at Higley's Point, about 1¼ miles above the toll-bridge.

Here it is proposed to construct a wing-dam, about 900 feet long, out from the east bank, just above the entrance of a small stream, as shown by a red line on chart No. 1, herewith submitted.

This, it is believed, will throw sufficient water into the channel to preserve the requisite depth at low-water for the ordinary traffic.

BAR AT BARBER'S LANDING.

The next place above Higley's Point that needs attention is near Barber's Landing, ¾ miles above Hartford. This bar is of the same general character as that of Higley's Point, being formed by the wasting of the water over the flat above, and crossing to the other side of the river. Here it is proposed to construct a wing-dam, about 900 feet in length, extending out from the east side of the river below the entrance of the small stream, in the position indicated by the red line on chart No. 2, herewith submitted. This wing-dam might, perhaps, be moved a little farther down stream, but it would come in deeper water and be, therefore, more expensive.

TUNXIS RIVER BAR.

Where the Tunxis or Farmington River enters the Connecticut, 5½ miles above Hartford, two extensive sand-flats have formed; one on the west side of the river, extending from the Tunxis about three-quarters of a mile up the river, and the other below, on the opposite side, extending down the river about half a mile. Between these two flats the bar has formed, reaching diagonally across the channel in the usual manner, before described.

This bar is shown on chart No. 3, and the sand-flats on charts Nos. 3 and 4, which are continuous, and join on the line *a b*.

Just below the mouth of the Tunxis the channel makes an abrupt turn to the westward, and continues down on the west side of the river with quite deep water. The bar runs for some distance between two deep pockets, and it is a matter of some doubt where it is better to deepen the channel across it. The position selected for a wing-dam at this place, shown by the red line on chart No. 3, extending out from the east bank nearly at right angles, is believed to be the best, as it changes as little as possible the present line of deepest water over the bar. This wing-dam will be about 500 feet long.

STRONG'S ISLAND BAR.

At Strong's Island, so called, although at ordinary low-water it is all covered, the principal bar is situated just below the flat or island, 6½ miles from Hartford. The channel follows the west bank of the river for about a mile above, and then crosses over the bar to the east side of the river. There is no channel to the eastward of Strong's Island, and just above it an extensive shoal reaches to the east bank. There is also another sand-flat above, bare at low-water. These are all shown on the accompanying chart (No. 4), which embraces the whole river up to the Scantic.

It is proposed to form a channel over this bar by means of a wing-dam, extending out about 1,100 feet from the east bank across the upper part of Strong's Island, as shown by the red line on chart No. 4. This will cut off the water now wasting to the eastward of the flat and over it at ordinary stages of low-water, and throw it into the channel.

Between Strong's Island and the Scantic there are some stumps in the channel that will be required to be removed.

SCANTIC BAR.

The bar at the mouth of the Scantic River, 7¼ miles from Hartford, is at present the worst place on the river. Opposite the mouth of the Scantic and a little above there is an irregular bar, as shown by the survey; but ordinarily no trouble is experienced above the main bar just below. This commences at a point near Bissell's Ferry, and runs diagonally across the river to a point near the upper part of Strong's Island Flat, about half a mile below. It leaves a large and deep pocket on the east side of the river just below the Scantic ferry landing, which extends some distance down the river, and was probably once the principal channel. The channel is now on the west side below Scantic Bar, and is quite narrow for some distance; but by the means proposed for improving the bar, the channel below will also be benefited.

By cutting off all the water from the present channel on the west side of the river, the water might be forced to follow the east bank at least as far as Strong's Island; but the uncertainty of changing the channel to this extent, as well as the increased expense, make the improvement of the present western channel preferable.

It is proposed to improve this place in the river by running out a wing-dam from the point of high ground just above the mouth of the Scantic diagonally down stream about 1,400 feet, then turning more parallel to the current, and continuing it about 600 feet farther down. This will cut off and turn into the channel most of the water flowing over the flat into the deep pocket above mentioned near the Scantic shore.

The proposed construction will interfere with the present ferry-landings, but it is not seen how it can be avoided without greatly increased expense. By moving the ferry-landings a few hundred feet, which would come more nearly opposite the road leading to East Windsor Hill, the ferry can be operated below the proposed dam.

A portion of the structure might be left off for a time to see the effect, and it might not be necessary to continue it so far down as to seriously interfere with the present road and landings.

THE CHARACTER OF THE WING-DAMS.

The river, through the whole length of the part embraced in the proposed improvement, is much wider than the average for the same distance below Hartford at ordinary stages of the water, although at extreme low-water some few places become narrower. Wherever the bars form the river is wide, and the proposed wing-dams are therefore quite long. In order not to interfere too much with the regimen of the river at

higher stages of water, it seems desirable not to make these dams too high. A height of 2½ feet above low-water mark has been assumed for all of them, which reaches to the ordinary low-water level or a little above.

The section assumed is to have the top 3 feet in width, and the slope on each side one horizontal to one vertical.

The best material available for the construction of these embankments is the broken stone and waste from the sandstone quarries on the river. This will form a permanent construction not likely to be washed away during freshets, and will probably be found to be the cheapest mode of forming suitable wing-dams.

Stones of various sizes can be thrown in at random from scows until the dam is built up to the dimensions described. It would not be water-tight, but sufficiently compact to offer the requisite obstruction to the flow of water.

There are large quarries at Portland, 16 miles below Hartford, with great quantities of waste lying close to the bank of the river, and also a quarry at East Windsor, about 9 miles above Hortford, with a railway to the river-bank and good facilities for loading the stone into boats.

A suitable stone could probably be found at other points on the river and quarried especially for this work, although perhaps it would not be so cheaply obtained.

ESTIMATE OF COST.

Wing-dam at Higley's Point, 600 cubic yards, at $3	$1,800 00
Wing-dam at Barber's Landing, 900 cubic yards, at $3	2,700 00
Wing-dam at Tunxis River, 700 cubic yards, at $3	2,100 00
Wing-dam at Strong's Island, 560 cubic yards, at $3	1,680 00
Wing-dam at Scantic River, 2,880 cubic yards, at $3	8,640 00
Removing stumps	80 00
Surveys already made, &c	3,000 00
Total	20,000 00

IMPROVEMENT OF ENFIELD FALLS.

My attention is called in your communication of February 23 to a letter from Mr. Charles E. Buell, of Springfield, Mass., to Mr. Minot in regard to improving the Connecticut River above Hartford, with a desire that I will consider it in making up my report.

Mr. Buell says: "Every effort should be made to keep the appropriations from being expended except on the Enfield Falls, and to avoid the use of the present canal; or else every business interest above Windsor Locks must pay an unnecessary tribute to the canal company, while a trifling increase in outlay will give us a *free highway*, besides adding other valuable advantages, if a dam was constructed across the river at the foot of the falls."

There is no doubt that the canal at Enfield Falls is a great disadvantage to navigation above, and, if possible, should be avoided. From the foregoing statements and estimate it will, however, appear that the amount already appropriated will not more than cover the expense of the necessary improvement of the river up to the lower end of the canal. There seems to be no necessity for work on the Enfield Rapids until the river is in such a condition that they can be reached from below.

From my present knowledge of the river I should say, however, that in the higher stages of the water the channel becomes navigable below the canal before it is passable at all over the rapids; and that when the water rises much above the ordinary level boats can ascend or descend the river without passing through the canal, although the ascent is difficult.

The prevailing stage of the river during the months open to navigation is from 1 to 2 feet above low-water mark, at which stage the rapids are totally impassable, and the canal is used by such boats as can pass in the channel below to ascend the river.

Under these circumstances, there seems to be no doubt that the channel below the canal should be first improved, so as to make the communication with the river above good at all times.

With regard to further improvement there is some question whether it is best to improve the present canal by widening and lengthening its locks, or to try to benefit the river-channel in some other way.

I have not heretofore considered this question, as the appropriation already made would not more than meet the requirements below, and is totally inadequate to meet the expense of improvements on the canal or over the falls.

It is suggested by Mr. Buell, in the letter above mentioned, that a dam should be built at the foot of the falls. But he does not say how that is expected to benefit the navigation. He probably intends that a series of locks shall be made in connection with it, to raise and lower the boats between the two levels, which would be from 25 to 28 feet.

This plan is practicable in an engineering point of view, but there are several objections to it as a means of improving the navigation of the river. In the first place is its cost. The dam at Holyoke, of about the same height and less width, has cost $600,000, the main dam having been built twenty years ago, when prices were much lower than now. The proposed dam, with its locks, would be, roughly, say, $250,000 more, or $850,000; an amount that it is not at all probable would ever be appropriated for the navigation that exists above Hartford.

The dam proposed would prevent all navigation except through the locks. No opening could be left, as in the present dam at the head of the falls, for boats to pass at high-water.

The cost for attendance on the locks would probably cost more than the tolls through the present canal, which are stated to be $1,200 for the year 1869. If a dam were possible, on account of the expense, the proposed plan is probably not the best. A dam at the head of the falls and a canal around the rapids would probably prove cheaper and safer, and could be built more permanently at less cost.

It appears to me, however, that all such questions involve too great an outlay for the benefit derived. If the river between the points embraced by the canal can be improved so as to be passable for boats to a greater extent than at present, it would seem desirable to expend any future appropriations in that direction, especially as the dimensions of the locks in the present canal are far too small.

The canal is owned by the Connecticut River Company, chartered by the State of Connecticut for the purpose of improving the navigation of the river between Hartford and Springfield; and they have the right to make improvements anywhere on the river above Hartford. It does not appear, however, that they have ever done any other work than build the canal and dam, which latter, the charter provides, shall not interfere with boats ascending and descending the river. This it certainly does at the present time. The opening originally left in the dam has since been partially filled up by the company with blocks of stone.

The charter provides for commissioners, appointed by the governor and confirmed by the senate, who have power to stop the tolls on the canal whenever the company do not comply with the terms of the charter, and it is extremely doubtful if the present state of the canal and river would not warrant them in so doing.

A full investigation of all the facts connected with the river, and also with the rights of the Connecticut River Company, as well as a full and complete survey, will be necessary before deciding where future appropriations should be expended.

List of accompanying maps and charts.

1. Chart of Higley's Point Bar.
2. Chart of Barber's Landing Bar.
3. Chart of Tunxis River Bar.
4. Chart of Strong's Island and Scantic River Bars.
5. Map of the Connecticut River from Hartford, Conn., to Hadley, Mass., compiled from the latest county and town maps. The river from Hartford to Scantic is from actual survey.

Very respectfully, yours,

THEO. G. ELLIS,
Civil Engineer.

Maj. Gen. G. K. WARREN,
Major United States Engineers.

The wing-dams recommended in this report were partially constructed in the summer of 1871.

That at Scantic Bar was commenced first, and was built out to a point 150 feet below the angle shown on the map of the river, Plate I, and was stopped then to determine whether the required effect would not be produced without interrupting Bissell's ferry just below.

The result obtained was so satisfactory that the dam was not extended farther; but the ferry is said to be much damaged by the accumulation of sand below it.

The wing-dams at Strong's Island and Tunxis River Bars, shown on Plate I, were then commenced, and were nearly completed before the close of the working season, about the middle of November.

The next year the water remained high late into the summer, and no work was done. In the summer of 1873 the water was again low and trouble was experienced at Barber's Landing Bar by boats running up the river. An examination of the effect of the wing-dams already built showed that the channel had been deepened by their action to about 3 feet, and it was also found that the bars at Barber's Landing and Higley's Point had materially changed their positions, so that the wing-dams, as originally proposed, would be too far up stream. Owing to the uncertainty of the action of the river at these places the improvement by wing-dams was given up for the time,

d in the summer of 1873 a channel near the west bank of the river at Barber's nding was dredged out. As the channel of the river formerly ran in this place, and e banks had not materially changed, there was some hope that a permanent diver- n might be made which would deepen the water.

The next season, however, found the dredged channel entirely filled up, and the oalest part of the bar somewhat farther down stream than before.

It will be seen from the map of the river, Plate I, upon which the proposed wing- m of 1871 is shown, that it would have been of doubtful expediency to have con- ructed it.

The charts of the several bars referred to in the foregoing report showed the bars as ey existed at the time of the survey in January, 1871, before any of the wing-dams ere constructed; but the localities are shown on Plate I of the map of the river here- ith submitted, as resurveyed in 1873, reduced from the large sheets of the survey om Hartford to Holyoke. The changes, however, except in the immediate vicinity the wing-dams, are not important.

The map of the river from Hartford to Hadley was mostly compiled; whereas the ap now presented is from actual survey, and shows all the points referred to in the regoing report, in many respects better than that originally accompanying it.

SURVEY OF ENFIELD RAPIDS.

In continuation of the general plan of improvement above Hartford, it became ecessary to provide for some means of passing over or around the Enfield Rapids, bove the improvements contemplated in the foregoing report. A survey of that por- ion of the river embracing the rapids and the Windsor Locks Canal was, therefore, ade in the summer and fall of 1871, commencing on the 22d of June and continuing ntil the middle of November.

The following report was made of this survey, recommending a canal around the rapids. The map accompanying the report showed the different plans proposed in lines of different colors. All of these lines are transferred to the general map of the river, Plate II, on a reduced scale; but in place of the colors the several lines are marked with the number of the proposed plan.

The "sections" referred to in this report commenced at the foot of the old canal, and were, at about 500 feet intervals, numbered up the river. Their position can readily be found by the scale.

HARTFORD, CONN., *January* 10, 1872.

GENERAL: In pursuance of the improvement of the Connecticut River above Hartford, as provided for in the appropriation act for the improvement of rivers and harbors, approved March 3, 1871, a survey has been made of the Enfield Rapids, in the State of Connecticut, with a view to ascertain what improvement can be made at this place to enable boats of a sufficient size to pass, at all times, and at the different stages of the water, to the navigable portion of the river above.

SURVEYS.

The surveys of these rapids have been made during the past season, in connection with the improvement in progress below.

An accurate map of this part of the river has been made, showing the banks and adjacent roads and buildings, and everything that would be likely to be affected by canals upon the banks, or dams constructed across the river-bed.

Sections have been carefully leveled over at distances of about 500 feet apart, extending through the bed of the channel to such a distance on each side as would be likely to be embraced in any proposed improvement.

Bench-marks were established by careful leveling from the low-water gauge-mark at Hartford, and the height taken of all high-water flood-marks that had been preserved by different persons, and of all the lowest water-marks that could be ascertained.

The field-work was in charge of my principal assistant, Mr. Charles L. Burdett, civil engineer, who made the survey of the shore-lines, roads, and buildings, and ran the section-lines across the river. He also made part of the soundings in the bed of the river.

The levels were taken by Mr. Henry W. Ayres, civil engineer.

Much of the survey of the section-lines, and leveling over them, was very difficult, the whole party being sometimes obliged to remain in the water all day.

The deepest parts of the channel on the more level parts of the rapids were sounded from a boat, but the velocity of the current, and the rocky character of the bottom in the more rapid and shoaler portions of the river-bed, rendered the operations of measuring and leveling both difficult and dangerous.

The party consisted at times of Sub-Assistants Ben. A. Cooke and George A. Paine, 2d, and of Oliver Dening, George T. Arthur, Wilmot Horton, and Eugene L. Avery, who all deserve credit for the willingness with which they performed the disagreeable

duty of working in the water, notwithstanding some of them suffered from ind position in consequence of the continued exposure. The whole party performed wh ever duty was required of them, without regard to the capacity in which they w employed. The same party were engaged, when necessary, in field-work on otl parts of the river where work was in progress, thus saving the expense of anot party on the improvements below, whose services would not be constantly required

DESCRIPTION OF THE RAPIDS.

The Enfield Rapids commence at a point about sixteen miles above Hartford, Co and eight miles below Springfield, Mass., and extend down the river to about op site the village of Windsor Locks, a distance of 5¼ miles.

At a distance of 10,400 feet below the head of the rapids is King's Island, 5,200 in length and 1,650 feet wide, which separates the stream in two parts, the gre volume of water passing to the eastward of the island. The banks of the island of rock, and its westerly side is a rock-bluff, showing a strata dipping to the north at an angle of about 7°.

The bank of the river on the easterly side, from the head of the rapids down to the upper end of the island, is steep, and partly of rock, which is covered with sa loam. Just above the island the shore is lower and sandy, and is partially overflo in high freshets. At this place there is a small number of buildings, as shown on map. Below this, extending to a point below the *New Haven, Hartford and Spri field Railroad bridge, the bank is again steep and rocky, after which it grows flat and is subject to overflow in high freshets.

On this side, at the lower end of the rapids, is the village of Warehouse Point, a p of which along the shore is shown on the map.

Back of the immediate bank, along the easterly side, the ground gradually rises. streams of any size and but two small brooks enter the river upon this side.

On the westerly side of the rapids is the canal of the Connecticut River Compa which will be referred to hereafter. The tow-path is immediately next to the stre Beyond the canal, for nearly the whole length, to below the railroad bridge, the gro is mostly high and forms a steep slope, in which the canal forms a side-hill cut, pa of solid rock.

Below the railroad bridge, at the foot of the rapids, extending for little more t a mile, is the village of Windsor Locks, part of which, along the river, is shown the map.

For about a mile along the tow-path of the canal, between it and the river, are m large manufacturing establishments, which use the water from the canal for po and discharge it at a lower level into the river.

The track of the New Haven, Hartford and Springfield Railroad passes through village just west of the canal, running nearly parallel to it, and crossing both it the river by one bridge above. After crossing the river the railroad keeps upon east bank, as shown on the map.

Between the villages of Warehouse Point and Windsor Locks there is a swing-f near section 9, as shown on the map.

The bed of the stream is rock, and also the banks generally above the island. B the island the substratum of rock on the banks is covered with sandy loam and gr The branch of the river to the westward of the island falls more rapidly at its u end than the main channel, and is consequently at low-water some 5 feet lower the middle of the island than the surface in the other branch.

Levels taken over the rapids at a low stage of water, in the month of October give the total fall from still water above the rapids to still water below at 31.8.

At the foot of the rapids the very lowest water deduced from levels taken at lowest stage during the past summer, which was an extremely dry season, and water was probably as low, within about an inch, as ever occurs, is supposed to b feet lower than the levels taken in October.

Just above the partial dam at the head of the rapids the water may perhaps f of a foot below the height when leveled over in October.

Below the dam, according to an authentic low-water mark as the lowest ever reac the water falls 1.4 feet below the height of surface when leveled over.

At intermediate points between the head and foot of the rapids the lowest w varies from one to two-tenths of a foot to 1.4 feet below the stage when leveled

At the lowest stages of the river the water tumbles over the rocky bed in su manner that the surface sometimes falls laterally across the stream 1 or 2 feet, so render it difficult to get the relative levels of the lower stages.

From the foregoing it will be seen that at the extreme low-water we should ha fall of 33 feet from the surface of the water above the dam to the still water below rapids.

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*Now the New York, New Haven and Hartford Railroad.

rface of the water over the rapids at the lowest stage leveled over is formed rincipal inclines or slopes, two of which are much steeper than the others. cing at the upper end of the rapids they are as follows:

Distances.	Fall.	Fall per mile.
Feet.	*Feet.*	*Feet.*
4,800	10.1	11.11
7,600	1.7	1.18
8,800	17.8	10.68
6,500	2.2	1.79

t slope reaches from the head of the rapids to Enfield bridge; the next to posite the middle of the island, in the east branch; the next to just below the Windsor Locks, and the last to the foot of the rapids.
er stages of the water the slope becomes more uniform. When the height of Hartford was 10.25 above the 0 of the gauge at the toll-bridge, or about one- he greatest height of freshet, the slopes on the rapids were as follows:

Distances.	Fall.	Fall per mile.
Feet.	*Feet.*	*Feet.*
4,800	7.3	8.03
7,600	4.3	2.99
6,800	12.8	9.94
8,500	1.6	.99

ighest water, or the freshet of May, 1854, which was the greatest freshet n on the Connecticut River, the slope was ascertained by levels over the he height of that flood, which have been preserved by different persons, to ws:

Distances.	Fall.	Fall per mile.
Feet.	*Feet.*	*Feet.*
9,400	8.9	5.00
10,300	8.7	4.46
8,000	0.0	0.00

ch called level is averaged through eleven different flood-marks of the freshet at were leveled over, none of which were more than .6 of a foot from the ine.
gh-freshet lines of the years 1854, 1857, and 1869, of which the levels were this part of the river, all seem to make the surface over the lower part of the e instead of fall. The slope must be exceedingly small, and the uncertainty ount at extreme high-water is such that a level is assumed as being practi- surface-line for a distance of 8,000 feet.
the rapids the slope of the river at extreme low-water to Scantic Bar is 1.7 miles, or .49 foot to a mile. The high-water slope is between the same points ot, or .17 foot to a mile.
Scantic Bar to Hartford, a distance of 7½ miles, the extreme low-water slope is or $\frac{5}{10}$ foot to a mile. The high-water slope between the same points is 2.4 feet, t to a mile.
are two bridges over the rapids, one at Enfield, 4,800 feet below the head of ls, with six spans of 124 to 176 feet, and rectangular piers of rubble masonry uality, with a flat slope up stream originally covered with a plank as a pro- gainst ice. The bridge is a wooden lattice, continuous over the piers, and is ble-down and unsafe condition, being in some places very badly strained and The whole is covered with sheathing to protect it from the weather. The f the bridge is 9.2 feet above the tow-path of the canal.
her bridge, situated 12,200 feet farther down, is that of the New Haven, Hart- Springfield Railroad. It is a fine iron bridge of recent construction, with piers, and spans as follows:
) feet, over the canal.
feet, over the tow-path.
feet, called the draw-span.

12 of 88½ feet, over the river.
1 of 177 feet, over the channel.
1 of 25½ feet, over a roadway at the east end.

At the head of the rapids is a dam about 3 feet high, extending nearly acros river, with an opening near the middle of 150 feet, which was originally left for passage of boats and rafts. The ends of the dam are higher than near the middle.

The opening was passable for boats some twelve or fifteen years ago, but since t time has been gradually filled up year after year with stone thrown in by the Con ticut River Company, nntil it is now impassable, the water being only about 1½ deep where it passes through the dam.

THE CONNECTICUT RIVER COMPANY.

The Connecticut River Company have a canal around the rapids, commencing at dam above mentioned and following the west bank of the river about 5½ miles to below the village of Windsor Locks. This canal is constructed on the river-bank, side of the natural bed of the stream, by cutting into the side-hill and formin embankment upon which is the tow-path. The depth varies from 4½ to 12 feet, the width from 44 to 160 feet. Above the village of Windsor Locks it is mostly o average width of about 80 feet, and through the village it will average about 55 in width.

At the upper end of the canal is a guard-lock 19.4 feet wide, and 91 feet long betw the quoins, for the purpose of admitting boats at high-water, and also gates to r late the flow of water into the canal.

At a distance of 250 feet below Enfield bridge crossing there is a set of stop-g by which the water above them can be raised five feet to equalize the pressure in and out, and render the embankment more secure in times of high freshets.

Opposite King's Island the canal crosses over Stony Brook by means of an aqued This has a width of 79.2 feet, and a depth of 5 feet.

At the lower end of the canal there are three lift-locks, of 19 feet width, and 90 long between quoins. These locks were poorly constructed, and are at the pre time in bad condition. The middle one has the sides pressed inward so as to mea but 18.4 feet in one place.

Through the village of Windsor Locks the water used for manufacturing pur now furnishes the company its principal revenue. The manufacturing establishm are on the tow-path side of the canal, which is here crowded by the railroad and cipal streets of the village, so as to be in one place but 44 feet wide.

The Connecticut River Company was chartered in May, 1824, by the State of necticut, with the following powers, among others:

"That the said corporation, for the purpose of widening the channel of said r and deepening the same, shall have power to dig, cleanse, and remove obstruc from the channels and bars of said river, from and above the bridge at Hartfor Springfield, and to erect and build wharves and piers and hedges in said river, the banks thereof; and the said corporation are empowered to lock the falls at En on said river, and to make channels to aid them, and to construct a canal on e bank of said river near said falls, and to construct a dam or dams for the purpo entering or leaving the locks in still water; provided the extension and form th shall be such as shall not prevent the convenient passage of boats and lumber d the river, nor obstruct the passage of fish."

The act also provides for a board of three sworn commissioners, "under whose d tions the necessary canal shall be laid out, and who shall inspect the constructi the locks and dams in said river, and cause them to be so constructed as they shal impede the progress of fish up the river, or the passage of floating boats, timber, o other property down the river."

All the ordinary and necessary powers were given to the company in the act, the commissioners were given power to inspect the locks, canals, &c., and when o repair or improperly tended, to direct that no toll be taken until a certificate sh be given by them that all necessary repairs were made and suitable lock-tender ployed.

The tolls allowed by this act were 50 cents per ton of loading for ascending b and 17 cents per ton for all descending boats and rafts; empty boats passing thr the locks, $1.

Vacancies in the board of commissioners were to be filled by the governor, wit consent of the senate.

An addition and amendment, passed in May, 1825, recites that "the capital sto said company may be expended between Hartford and the north line of this Sta Long Meadow, and West Springfield, in the State of Massachusetts, and also t proving the navigation above this State toward the sources of Connecticut Rive toward the Lake Memphremagog, in the State of Vermont, so far as shall be de practical and expedient, lawful authority for so doing being had and obtained; a

may purchase, repair, construct, and hold such works as shall be deemed neces-
erfect and complete said navigation."
ıme act provides: "The stockholders of the Connecticut River Company, their
s, successors, and assigns, are hereby incorporated and made a body politic,
on in law, by the name of The Connecticut River Banking Company," &c.,
ıem powers necessary for the business of a banking company. The Connecti-
r Company were authorized to organize the Connecticut River Banking Com-
en they had actually expended the sum of $200,000, and obtained the certifi-
ıe commissioners to that effect.
, 1828, an alteration of the charter was passed, authorizing the formation of
ecticut River Banking Company when $100,000 had been expended, and pro-
ıat the powers of the said banking company shall cease unless a good and
e canal and locks by Enfield Falls shall be completed by the Connecticut River
within two years from the rising of the assembly.
, 1829, a resolve of the assembly authorized the Connecticut River Banking
to subscribe to the stock of the Connecticut River Company to the amount
), and also extended the time for the completion of the locks and canal around
'alls to two years from the rising of that assembly.
, 1825, the general assembly of the State of Vermont passed an act, to take
en assented to and confirmed by the States of Massachusetts, Connecticut, and
ıpshire, incorporating, under certain restrictions, The Connecticut River Com-
ring them various powers; among others to purchase land, and to enter into,
, and possess so much of the banks and waters of said river, and the lands
thereto, as shall be necessary for effecting in the best manner the objects of
and may dig, cleanse, and remove obstructions from the banks, channels, bars,
ds of said river; may construct dams, canals, locks, towing-paths, and rail-
ıere it shall be deemed expedient, and other works beneficial to navigation.
t also gave the company power to purchase the franchises of other corpora-
the improvement of the navigation of the Connecticut River, when the pro-
of one-half the stock should agree to sell.
also enacted that, as soon as said company shall have constructed suitable
enient locks and canals, so as to permit the passage of boats of 66 feet long
et broad, at or near the following places, viz: By Enfield Falls, in the State
cticut; near the north part of Hatfield or Hadley, in the State of Massachu-
School Meadow Bar, in the States of New Hampshire or Vermont, viz, near
Rocks, in Hinsdale or Vernon; in Hinsdale or Brattleborough, near the bridge
ınnecticut River; in Westmoreland or Putney, near Clay's Island; in Charles-
Springfield, near Gill's Island; in Cornish or Windsor, near Chase's Island; in
r Fairloe, near Flag Island; in Haverhill or Newbury, near Johnson's Rocks;
near the mouth of Wells River, in Bath or Ryegate, near Dodge's Falls; and
r the said company shall have acquired the right to the locks, canals, and
r improving the navigation of South Hadley Falls and Miller's Falls, both in
e of Massachusetts; at Bellows Falls, in New Hampshire and Vermont; at
ueechy Falls and at White River Falls, they may demand and receive tolls
ceed a list given. The rates for Enfield Falls were 50 cents per ton for each
g boat, and $2 for each descending boat. The company were required by this
aintain a depth of at least 3 feet in the canals and in the river below to the
ıal, and below the Enfield Falls Canal to the city of Hartford; "and if the
th shall not continue without interruption between Enfield Falls and the city
ord, the commissioners may reduce or prohibit the taking of tolls." This act
firmed by the State of Connecticut, November 9, 1825, with the limitation,
thers, that nothing in it should authorize the company to erect or construct
ts which should in any way obstruct or impede the free navigation of the Con-
River.
present time the amount of the capital stock of the Connecticut River Com-
203,500, and its present value is about 50 cents on a dollar, or $101,750.
lls now collected are 15 cents per ton for ascending boats, and $2, empty, for
ng boats; amounting to about $1,200 a year. The amount received by the
for water-rents is about $15,000 a year.

THE RIVER BELOW THE RAPIDS.

r to properly consider the nature of the improvement required, it is necessary
the character of the river and the facilities for navigation above and below
s at the present time.
he mouth of the river to Hartford, a distance of 49 miles, the channel is
for boats of 8 feet draught at the lowest stages of the water. This is about
e than the river in its natural state at all times permits. The channel has
erially deepened and widened by the dredging done by the United States
nt during the past two seasons.

The navigation, as far up as Hartford, is favored by the tides, which average about 10 inches in height at that place. This rise of tides is in addition to the depths given above, so that boats drawing from 7½ to 8 feet have been for many years used upon this part of the river. The tides at Hartford, however, are not regular, varying from nothing to about 18 inches. Between Hartford and the foot of the rapids, a distance of about 11 miles, the channel is now in a bad condition, owing to bars, upon which there is only from 1½ to 2 feet in the deepest part at the lowest water. The channel is also in many places narrow and crooked. Works are now in progress by the United States Government which, it is hoped, will deepen the water on the bars to 3½ or 4 feet at low-water.

Owing to the increased slope of the river-bed, the tides rapidly diminish above Hartford; ordinarily, they are not noticeable at Scantic, 7½ miles above Hartford; but an exceedingly high tide, at a low stage of the river, is sometimes sensible as far up as the foot of the rapids.

There are two bridges below the rapids, at Hartford. One is the bridge of the Hartford, Providence and Fishkill Railroad, where it crosses the Connecticut; a wooden Howe truss, upon cut-stone piers, in a good state of repair. The other is the highway bridge from Hartford to East Hartford, an old, dilapidated affair, in which the subsequent additions barely hold up the original structure. Both of these bridges are provided with draws; that in the railroad bridge has an opening of 47 feet, and that in the highway bridge an opening of 17 feet.*

THE RIVER ABOVE THE RAPIDS.

Above the rapids the water is still and level, and good navigation to the village of Holyoke. There is one bar at Long Meadow Flats, upon which there is about 5 feet at low-water.

From the points named in the charter of the Connecticut River Company by the State of Vermont, it will be observed that it was contemplated to preserve a navigation of a minimum depth of 3 feet as far up as Wells River, or about 240 miles. All navigation, however, is now stopped above Holyoke. There was formerly a canal on the east side of the river at this place, extending around South Hadley Falls, but it is now entirely given up, and used only as a tail-race for the mills at its side.

The Holyoke Water Power Company, who built the present dam, have contemplated a new canal on the west side, in connection with their water-power, by which to pass boats around the falls. Their dam and canals are excellent, but the lock which they have put in to descend to the first level is much too small, being but 16 by 80 feet. At this place the whole fall is 58 feet. The first level is 20 feet below the dam; the next level 12 feet lower, leaving 26 feet to the still water below the falls. There is nothing to prevent a good canal being made at this place, as the lock already built can be enlarged without materially interfering with the water-power, and communication can be easily made from the canals to the river below the falls.

Between the head of the Enfield Rapids and Holyoke there is nothing less than 5 feet depth of water in the channel.

There are four bridges on this part of the river—two at Springfield and two above, none of which are provided with draws. They are, however, of such a height as to allow small steamboats to pass under them.

The canal at South Hadley Falls (Holyoke), and the one at Montague, above, were first chartered February 23, 1792. The dimensions of the locks were to have been 20 by 60 feet, but they were afterward permitted to be built 16 by 40 feet by an act of June 21, 1793. The charters of the two canals were separated February 27, 1794. The South Hadley Canal was first finished; it was 2¼ miles long, much of it through solid rock. At first the boats were hauled up an inclined plane by large water-wheels, but the bed of the canal was afterward deepened and locks were used. The lowering of the bed of the canal was completed at the commencement of the year 1805.

The canal at Montague was commenced in 1794, and completed four years afterward, in 1798. It was 3 miles in length, and reached from above Turner's Falls to the still water below. This canal was used for the transportation of merchandise for about fifty years, until the Connecticut River Railroad was finished, in 1848, when, from the railroad competition and its insufficient size, it was abandoned. It can now scarcely be traced, having been nearly obliterated by more modern improvements.

A new dam has been built by the Turner's Falls Company, and no provision made for water transportation.

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*There are at present two bridges below Hartford, one where the New Haven, Middletown and Willimantic Railroad crosses the river at Middletown, and the other where the Shore Line Railroad crosses at Lyme. The first named is an iron bridge with a double swing-draw of ample width, and the second is a wooden truss-bridge with an iron swing-draw of about the same opening as that at Middletown.

THE AMOUNT OF BUSINESS ON THE RIVER.

With regard to the amount of business on the river, no general estimate has been made of the total amount of freight and tonnage since 1867, when one was compiled, chiefly from the evidence given before a committee of the legislature upon the question of bridging the Connecticut River below Hartford. As this is quite reliable, it is given as the best means of computing the present amount of transportation. In 1866 the amount of freight upon the river was as follows:

	Tons.
Steamboats to and from Hartford	74,600
Freights to Hartford by propellers, &c	201,600
Down freight by the same	16,000
Total Hartford freight	292,200
Freight between Hartford and Middletown	24,000
Freight from Portland	220,000
Freight at places below Middletown	79,512
Total	615,712

In 1865 it was 569,000 tons. Allowing 40,000 per year increase, we should have for the year 1871 nearly 816,000 tons of freight passing on the river.

The amount received for freight in 1866 was $1,350,000. At the same rate of increase as for freight above stated in 1871, it would be about $1,800,000.

In 1866 the number of passengers to and from New York by steamboat was	26,211
Way passengers on the river	27,208
By Sag Harbor steamboats	10,000
	63,419
The total amount received from passengers by the steamboat company was	$125,550
By Sag Harbor boat, about	8,000
Total	$133,550

The number of trips to and from New York and Hartford by the steamboat company's boats was	1,117
By the Sag Harbor boats	208
By sailing-vessels and propellers	1,836
Total number of trips	3,161

During the past season there have been upon the river five large steamboats, forming two daily lines to New York, and three smaller ones; one making daily trips to New London and Sag Harbor, and another making two trips a day on the river between Hartford and Essex. There is, also, a line of propellers running to Albany, and one to Philadelphia.

The river remains open for navigation an average of nine and a quarter months in each year. It closes about the 8th of December, and opens about the 1st of March. For sailing-vessels the time is about eight and a half months.

With regard to the business above Hartford no definite estimate can be made of what would probably pass by water communication instead of by railroad, if the river were navigable to Holyoke by the proposed improvements.

From the size and population of Springfield, Chicopee, and Holyoke, with the great water-power and prospective growth of the latter, it is but fair to presume that the water transportation above Hartford would be considerable, and that all heavy freight, such as iron, coal, stone, bricks, lumber, &c., would be carried by water direct, instead of being transhipped by railroad to the points named. The actual amount of the above materials used has not been ascertained.

AMOUNT OF REVENUE IN THE DISTRICT.

The amount of revenue collected at the Middletown custom-house during the year ending June 30, 1871, was $13,664.79. On June 30, 1871, there were registered in the district 150 vessels, with an aggregate tonnage of 18,458.37 tons. During the year there were built and employed in the district 14 vessels, with a tonnage of 1,964.55 tons.

IMPROVEMENTS OF THE RAPIDS.

In arranging plans for improvement of the Enfield Rapids, the question arises whether any plan should be considered which would entirely close the navigation through the

ordinary channel of the river. The charter of the Connecticut River Company, and the concurrence by the Connecticut legislature in the act passed by the State of Vermont in 1825, incorporating the Connecticut River Company, expressly state that nothing shall be construed to empower said company to build a dam at Enfield Falls in such a manner as shall prevent the convenient passage of boats and lumber down the river or obstruct the passage of fish.

Notwithstanding these provisions, the Connecticut River Company have constructed a dam across the river at the head of the falls, which is at present impassable for any purpose of navigation. The opening of 150 feet originally left in the dam has been gradually filled in by the company, until now there is an effectual bar to navigation, unless it be in very high water, when boats might descend.

The channel of the river is now of so little use that there seems to be little or no objection to constructing dams so as to wholly cut off the outside navigation in the natural channel, if the improvement proposed should furnish adequate facilities for the passage of anything that might have occasion to pass the dam. In the plans of improvement proposed, therefore, entire dams across the river will be considered.

With regard to the interference of the franchise of the Connecticut River Company with any plan of improvement, it is assumed that, unless their property is actually taken or their water-power interfered with, no damage will be done to them by withdrawing the navigation from their canal, nor is it supposed they would expect or demand any compensation. The canal at present is totally inadequate to pass such boats as would undoubtedly be used if they could get up the river, and the water transportation has consequently diminished to such an extent through their small locks that the company will probably prefer to give it up altogether, and use their canal entirely for manufacturing purposes, if the government should otherwise improve the navigation over the rapids.

THE DIFFERENT PLANS PROPOSED.

The plans which will be considered for improving navigation over these rapids are

First. A canal on the west side of the river, extending from the present dam at the head of the rapids, parallel to the old canal, down to a point just above the village of Windsor Locks, and a channel to the deep water below, formed by excavatin the bed of the river.

Second. A canal on the east side of the river from the dam above to the deep water below the rapids.

Third. Damming the river at the island, or a little below it, and continuing with a canal below upon the east side of the river.

Fourth. Damming the river at a point near Enfield bridge, and locking to the river below, damming it again just below the railroad bridge, near Windsor Locks, and continuing with the canal to the foot of the rapids.

Fifth. Improving the old canal so as to be navigable for boats of increased size.

THE FIRST PLAN.

In the first plan it is proposed to make a canal 150 feet wide, parallel to and just outside the old canal, except opposite the island, where it widens out into a basin, with locks 200 feet long between the quoins and 50 feet wide. At the head of the canal a guard-lock would be required of the above dimensions and 12 feet lift; also a bulkhead of masonry, with gates for regulating the supply of water to the canal.

An embankment of 10 feet width on the top and slopes of 1½ horizontal to 1 vertical will be required from the guard-lock at the head of the canal down to the upper end of the island. The top of this is intended to be at a level of 2 feet above the freshet of 1854, which is the highest known. This embankment is to have a riprap of rock 2 feet in thickness upon its outer slope, and 1½ feet in thickness upon the top and inside slope. The width of the canal is limited in this part of the river to 150 feet, so as not to encroach too much upon the bed of the stream, and thereby materially diminish the water-way, which is already somewhat contracted.

West of the island the whole of that branch of the river is taken into the canal, the island forming the embankment for about one mile in length, and inclosing a basin of about 600 feet in width. At the foot of this basin, near section 25, shown on the accompanying map, would be the first lock, having an 11-foot lift.

Opposite the island a small stream, called Stony Brook, enters the river, passing under the old canal. Upon this stream, about 1,000 feet from the river, is a water-power of 28 feet fall, having the top of the dam 16.5 feet above the proposed level of the canal-basin. The water would have to be turned into the canal, as there seems to be no economical manner of disposing of it otherwise. The water-power would be damaged by reducing the fall to 16.5 feet. The volume of water discharged by this stream during the greatest freshet is about 4,000 cubic feet per second, but only for a very short period of time. At ordinary stages the discharge is, perhaps, not over 100 cubic feet per second.

ection 25 a dam will cross the westerly channel between the island and the path. At the west end of this dam it is proposed to place the first lock, while of the dam will serve as a waste-way to dispose of the surplus water coming canal from Stony Brook during freshets. The width of this weir would be 0 feet, and it is believed, from inquiries and observation, that the water run- the reach would never amount to more than 1½ feet in depth over the dam; area of the surface of the reach equalizing the sudden rush of water from owers.

xt lock would be about a mile below, near section 15 on the map; near this ld also be a small waste-weir. This lock would be of similar size and con- to the one above, and of the same lift.

ird and last lock would be situated just above the manufacturing establish- the old canal-bank in the village of Windsor Locks, near the present waste- he old canal. It would be like the others, and of the same lift of 11 feet.

nbankment from the island down to this lock it is proposed in the estimate of the same height as the one above, or 2 feet above the highest water. This nent between the last two locks might, however, be dropped down to a lower easen the cost, but it would not give so plain an entrance into the canal when r lock was flooded.

the last lock it is proposed to excavate a channel in the bed of the river for 00 feet in length and 150 feet wide, to a depth of 5 feet at extreme low-water, 6½ feet at an ordinary low stage of the river. This channel will lie in such a that it can be easily followed.

ck excavated can be used partly for the embankment above and partly thrown e side toward the river, to check the lateral flow of water into the channel, he surface of the water within it will have a less slope than the surface of the t low-water the slope of this part of the river is 2 feet to the mile, which di- as the height increases, so that, at 6 feet of water, the slope is 1 foot to the d at high freshets it is practically level.

canal it is proposed to make the depth on the miter-sills of the locks 6 feet. ed of the canal there will be no depth less than 8 feet.

-path must be excavated on the west side of the island, along the side of the it is considered desirable to have a continuous tow-path on the embankment he canal. It is included in the estimate for this plan.

two lower reaches there will be some excavation required to get a depth of 8 he bed of the canal, but the amount is small, and will be more than required mbankment, which is in excess. The cost of making the canal 8 feet deep is er than for a less depth. This canal would pass under Enfield bridge, leaving bove the surface, and under the railroad-bridge, leaving about 29 feet.

are no draws in these bridges, but the railroad-bridge has what is called a span," under which the canal would pass. The charter of the company obliges have a draw, but the navigation of the river outside the old canal has never ed them to comply with it. If the new canal should be constructed, they robably put a draw at this place. A road-bridge will be required at the lower r the canal, and a bridge over the top of the waste-dam at the upper lock. gth of this improvement would be 4.85 miles.

THE SECOND PLAN.

econd plan, of a canal on the east side of the river, would lose the advantage of ne mile of embankment, which is formed by the island in the proposed canal est side, but it could be continued lower down the river entirely to the foot of ds without interfering with the use of the old canal for manufacturing pur- nd thus dispense with the large amount of excavation in the bed of the river. turned into the river as high up as would be required on the west side, it pre- advantage, as the natural channel of the river is upon the east side, and might without any excavation, but it is considered too shallow and intricate for good ion. In this plan the guard-lock and bulkhead, with entrance-gates for the ould be the same as by the first plan. From the head of the canal the embank- uld be mostly in the river down to section 40; the canal would then pass out d of the river, and cut into the bank down to section 31. It then again runs ver to section 25, after which it cuts into the bank, passing under the railroad of the present bridge, and continuing back of the river-bank to section 4, enters the channel. There will be some rock-cutting to form a channel above r Enfield Dam, and also below the canal near section 4.

will be three lift-locks of the same dimensions as before named, viz, 50 by 200 r the railroad-bridge; the first near section 20, the second near section 7, hird near section 4 at the end of the canal.

nal is of the same width proposed for the other, viz, 150 feet. The two lower

locks would be flooded at high water, but a flood that would cover more than the first is extremely rare.

The reason for cutting into the bank and passing under the railroad, instead of following around the river-bank, is that for some distance above the bridge the bank is very much exposed to floating ice, which often piles up to a great thickness at this place, so that an embankment outside would be liable to destruction from this cause.

Below the bridge, through the village of Warehouse Point, the canal is kept back from the river to such a distance that the level of the water in it will not overflow and cover ground behind it, nor require any material quantity of embankment on the inside.

By dropping to the lower reach sooner the canal can be run along shore; but unless the embankment be carried above high water, the lower part of the canal would be occasionally overflowed and the entrances blind through the drowned portion.

This canal will require three waste-weirs near sections 5, 6, and 16.

The surface of the water in the canal will be 19 feet under Enfield Bridge, and 23 feet under the level of the track where it crosses the railroad.

A road in the village of Warehouse Point will have to be moved or closed, and some houses in the village will also require removal.

There will be required at least two bridges over the canal at Warehouse Point: one, a road-bridge, at the cross-street upon which the hotel is situated, and one (perhaps a foot-bridge) on the cross-street below. A small stream near section 19 will be carried under the canal by a culvert. Another small brook at section 36 will be turned into the canal. All other surface-drainage will be carried into the canal.

Below the lower lock there will be some excavation required in the bed of the river to get a clear depth of 6 feet. This is provided for in the estimate. The length of this canal would be 4.83 miles.

THE THIRD PLAN.

The third plan of damming the river at the island, and constructing a canal on the east side to below the rapids, requires one dam of 1,150 feet in length and 17 feet high on the east side of the island, near section No. 26, as shown on the map, and another at the head of the island crossing the west branch diagonally from the end of the island to the opposite shore above, of about 600 feet in length and 13 feet high. Both of these dams are of the same height as the Enfield Dam. This height would bring the top of the dam at the head of the island within 1 foot of the top of the tow-path of the old canal. As the proposed dam would have about 10 feet of water flowing over it in the highest freshets, the bank of the old canal must be at least 12 feet above, or 11 feet higher than it is now at this place. This height would have to be continued up the river, along the continually rising slope of the tow-path to the upper end of the old canal, a distance of 9,000 feet, where the filling would be about $\frac{1}{2}$ foot.

As, however, the usefulness of the old canal for purposes of navigation would cease upon the construction of more extended works by the government, it will be better to continue the dam directly across the old canal and arrange gates to admit and regulate the proper quantity of water needed for manufacturing purposes. This will be much cheaper than the long and heavy embankment required, and would be free from the great risk of leakage and rupture during freshets that would be incurred with the embankment. The old canal would be much safer than it is now, as much of the present tow-path is below the highest flood. By this plan the under side of the bridge at Enfield would come quite near the surface at high water. In the two preceding plans the water is confined to the canal, and does not rise with the river. Supposing the water to run over the dams 10 feet deep, it would leave a distance of only 9 feet under the bridge. At ordinary high water very few boats, if any, could pass. With this plan, therefore, the bridge would have to be raised or provided with a draw.

From the lower dam, at section 26, to the foot of the rapids, there would be a canal on the east side of the river, the same as in the second plan.

The guard-lock would be at the dam, and would have a ten-feet lift. The other locks would be exactly the same as before described.

The dams are estimated to be made of 12-inch by 12-inch chestnut timber, laid up in cob-work, inclining at an angle of $2\frac{1}{4}$ horizontal to 1 perpendicular, bolted together with iron bolts, and filled in solid with blocks of stone. The top surface is a complete layer of 12-inch timbers.

As these dams are so situated that the dip of the strata of the underlying rock is upstream, they will not be endangered by any excavation the water may make below them. They consequently will not need any apron or other expensive structure below, such as has been recently added to the Holyoke Dam.

At the east end of the east dam, near the guard-lock, there would be entrance-gates for the water, the same as at the upper end of the canal by the previous plans. The length of canal required by this plan would be 2.13 miles.

In place of the two dams above mentioned, one might be built just above the railroad-bridge, near section 22, as shown on the map. This dam would be about 1,300

feet long and 23 in height. Like the one at the head of the island, it would have to cross the canal also, and be supplied with gates to let the water into the old canal. This is the lowest down the river that a dam of the level of the Enfield Dam can be built. It cannot be placed below the railroad-bridge, on account of the height of the bottom chord of the channel-span, which is only 4½ feet above the required height of the dam, or 7½ feet below high water.

The bottom chords of the twelve river-spans of 88½ feet would also be 3 feet under water in the highest freshets.

A dam as proposed, between the railroad-bridge and the island, would set the water back in Stony Brook so as to damage the mill privilege, as mentioned in the first plan, diminishing the fall from 28 feet to 16.5 feet. The length of canal required by this plan would be 1.64 miles.

The estimates for the third plan are marked *a* and *b* for the two modifications above described.

THE FOURTH PLAN.

The fourth plan proposed requires two dams at different levels. The upper one is placed just above Enfield bridge, near section 46, so that the lower level reaching under the bridge would give a greater headway than in the previous plan. The top of this dam would be of the same level as low water above the rapids.

The next dam is placed at 11 feet lower level, just below the railroad-bridge, near section 21. This is done with a view to passing under the bridge already built, instead of making a new one east of it. If the dam is placed above the bridge, the masonry of the locks would contract the water-way, and be too much exposed to damage from ice, unless moved back so that the canal would pass east of the bridge, as in the before-proposed plans.

The average height of the upper dam would be about 10½ feet, and the lower one about 13 feet.

The upper dam would be about 950 feet in length, and the lower one 1,200.

At the upper dam there would be a guard-lock of 15 feet lift, and a lift-lock of 11 feet. These are best placed at the west end of the dam.

At the lower dam there would also be a guard-lock of 12½ feet lift, and a bulkhead with gates leading into the canal.

The canal in this plan passes along the bank of the river from the lower dam down to near section 4, as shown on the map, 150 feet wide, as in the other plans.

Through the village of Warehouse Point it would run in the river just outside of the river-road, and the water would be nearly up to the level of the road.

The embankment would be of the same character as heretofore described, and carried up 2 feet above high water.

There would be two lift-locks of 11 feet each between sections 6 and 4 at the lower end of the canal.

All the locks are of the same length and width as before described, but by this plan one more lock is required, viz, the guard-lock at the lower dam.

Two waste-weirs are needed just above the two lower locks, and a foot-bridge across the canal from the shore to the embankment.

This plan gives a height of 30 feet under Enfield bridge at low water, or 17½ feet at high water, and under the railroad-bridge a height of 28¼ feet at the draw-span, and 20 feet under the twelve river-spans at low water, or 16½ and 7½ feet respectively at high water. There is a narrow span of 25 feet at the east end of the bridge, which might be available at high water, under which there would be 18½ feet at the highest stages.

This plan would require the raising of the bank of the old canal, on account of the higher level to which the freshet-line would be raised. From the upper dam to the head of the old canal there would be about 3,500 feet including the guard-lock, which would be overflowed, and would have to be raised an average of 5 feet, and between the two dams there would be about 10,000 feet requiring to be raised an average of 2 feet.

The upper dam can, however, be carried across the canal, and provided with gates, as described for the third plan, so as not to require any alteration of the canal above the dam. This is the method provided for in the estimates.

The pond of the lower dam at the lowest water will cause back-water to the extent of about .5 of a foot at the lower water privilege on Stony Brook.

Some excavation will be required in the bed of the stream below the locks at the upper dam.

Below the canal there would also be required some rock excavation in the bed of the river, to get a clear depth of six feet. These are included in the estimate.

The length of canal required by this plan would be 1.50 miles.

THE FIFTH PLAN.

In the fifth plan, of enlarging the old canal, it is proposed to widen it to 150 feet, so as to give the same facilities to navigation as the other plans, by excavating upon the west side of the canal, and putting material upon the present tow-path, which is now a great deal too low, and in many places exceedingly weak.

At Enfield bridge, and at the railroad-bridge crossing the canal, it is proposed to leave the abutments as they are. The span of the bridge at Enfield is 124 feet, one pier being on the tow-path embankment. The span of the railroad-bridge is 140 feet, with the pier likewise on the present tow-path. These spans will allow sufficient space, although not so wide as the rest of the proposed canal.

The aqueduct where the canal crosses Stony Brook it is not proposed to alter. It is 79.2 feet wide, with water 5 feet deep, and is in pretty good repair. It would not probably be necessary to provide a new structure for many years.

Below the railroad-bridge the track would have to be moved to the westward, to accommodate the increased width of the canal, as shown on the accompanying map. Where it crosses the small water-course, just above the village, it will not be changed.

Through the village of Windsor Locks, the position of the canal is contracted, the width being much less than in other parts. On the east side it is limited by the tow-path, on which many large manufactories have been erected, and on the west side it is crowded by the track of the New Haven, Hartford and Springfield Railroad, and by the main street of the village. On this part of the canal it is proposed to widen to the required distance by taking property on the opposite side of the street, and moving over both the street and the railroad, as shown by the blue lines on the map. This will take all the buildings on the street between Burnap's hall and Browning's drug-store, requiring them to be taken down or moved back to the new line. Below this for some distance the houses stand back from the street, so that no buildings will be disturbed; but from Elm street to South street several more houses will require removal. These are shown on the map.

The railroad will be moved so as to run parallel to the canal on its west bank, and the new highway placed beyond it. At the present time this road is exceedingly unsafe, being for some distance nearly on a level with the track, and close to it. At one point the whole road and railroad occupy a space of only about 70 feet from the bank of the canal. With regard to safety and the general appearance of the street, it is believed that the proposed change will be a benefit.

The alterations proposed interfere somewhat with the railroad in giving less space for buildings, turn-outs, &c. It will also oblige the company to move the station-buildings to another locality.

It will also cause the removal of the store-house of the Seymour Paper Company, near the railroad-buildings, and the Dexter Mill farther down on the west bank of the present canal.

The bridges estimated for in this plan are of a similar character to those now used, which are but little elevated above the surface of the water, and are swing or floating bridges, used when boats are not passing.

The stop-gates which have been recently placed in the canal, just below Enfield bridge, will have to be removed.

A new guard-lock, of the dimensions before described, is to be constructed at the upper end of the canal. At the lower end new locks of the same dimensions are to be built. These will, on account of their size, be placed farther apart than those of the present canal. It is proposed to locate them a little to the west of the present position, so that they can be constructed without interrupting navigation through the old locks. In this plan the franchise of the Connecticut River Company will have to be purchased by the government, and there is no doubt that it could be obtained at a fair valuation, as the greater part of the stock is held by the Connecticut River Banking Company, and by the family of the president of the canal company. It could probably be bought for about $100,000.

An estimate is made upon this plan for a canal of 150 feet wide, in order to compare with the other proposed plans. This can be modified to save expense, even to narrowing down to the present width of the canal. In this case the cost would be reduced to the expense of putting in the new locks and the cost of purchasing the franchise of the old canal company. This might be all that would be required for some years, until the increased size of boats passing through the canal should necessitate its being widened.

An estimate has been made on this modification, and the two estimates for this plan marked *a* and *b*.

NO PLAN FOR IMPROVING THE NATURAL CHANNEL.

No plans or estimates are presented for improving the natural channel of the river, by excavation or otherwise, because such a work would not meet the requirements of

avigation, and would probably prove more expensive than those proposed.
seen in the description of the rapids that, at a low stage of the river, the
part of the channel is 11.11 feet per mile for a distance of 4,800 feet, and
per mile for 8,800 feet. An excavation in the bed of the river, or parallel
nts, to carry all the water, would form a mere chute, impracticable for
or descending boats. The mean velocity of the current would be about 5.2
hour, and a channel 6 feet deep and 88 feet wide would carry all the water
r at the lowest stages when running with this velocity.

ESTIMATES.

owing estimates are made for a canal 150 feet wide at the water-line,
s of 1½ horizontal to 1 vertical, both in the cuts and for the embankments.
r are supposed to be of earth raised in layers, so as to be water-tight with-
rate clay puddling in the middle, and to have a riprap of rock upon the
pe of 2 feet in thickness, and on the inside slope and top of 1½ feet in thick-

als are all estimated as 7 feet deep, with 6 feet of water on the miter-sills
water is at its minimum level.
sonry of the lock is supposed to be coursed rubble, of freestone, laid in
cement and grouted, with the gate-chambers, quoins, coping, and corners
masonry in the locks of cut granite.
sonry for the railroad-bridge abutments, entrance-gates at the heads of the
ste-weirs, and the abutments of the proposed dams are estimated as all of
estone rubble, with corners and coping having cut beds and builds. The
ge-abutments are estimated of uncoursed rubble, of stone in the vicinity,
ar cut corners and coping.
aining-walls are estimated as uncoursed rubble, laid in cement like the pre-

k-gates are supposed to be of ordinary construction, with white-oak timbers
sheathing, and to be opened and closed by capstans. All the dams are sup-
e constructed of a cob-work of 12-inch by 12-inch chestnut timber, with a
ce and a back slope of 2½ horizontal to 1 vertical, laid on the incline, with
sections at 5-feet distances, and the whole filled in solid with broken stone.
ce of the sloping back is estimated as of solid timber, 12 inches thick. The
ons of all the timbers to be bolted through with 1-inch iron bolts. No aprons
dams are included, as they are not considered necessary.
bankments are all estimated as 2 feet above the highest water. No account
of the slopes of the water-surface in the canals or between the dams. The
re considered level for the purposes of an estimate. This will be sufficiently
il the plan to be executed is determined upon, when the proper slope and all
s of the work can be accurately arranged.

Estimate for first plan.

ıbic yards earth embankment, at 45 cents	$193,374
ɔic yards rock embankment, at $2	163,500
ic yards earth excavation (foundations), at 60 cents	2,100
ic yards rock excavation (foundation), at $3	17,175
ıbic yards rock, channel below canal, at $4	404,400
ic yards rock-filling for waste-dam, at $2.50	7,505
ic yards clay puddling, at $1.50	1,800
c yards rubble in guard-lock, at $12	39,960
yards cut stone in guard-lock, at $20	13,520
c yards rubble in first lift-lock. at $12	39,780
yards cut stone in first lift-lock, at $20	12,900
c yards rubble in second lift-lock, at $12	39,780
yards cut stone in second lift-lock, at $20	12,900
c yards rubble in third lift-lock, at $12	31,560
ɣards cut stone in third lift-lock, at $20	12,900
ɣards rubble in gate-head, at $12	4,200
ɣards cut stone in gate-head, at $16	1,600
·ards rubble in waste-dam, at $12	11,400
ards cut stone in waste-dam, at $16	3,200
ards rubble in two waste-weirs, at $12	1,560
rds cut stone in two waste-weirs, at $16	480
ards rubble in road-bridge abutments, at $8	3,200
ırds cut stone in road-bridge abutments, at $16	1,600
ɣards rubble in retaining-walls, $8	10,560

2,700 cubic yards concrete, at $5	$1
408,000 feet (board measure) timber in waste-dam, at $45	1
36,800 pounds iron bolts in waste-dam, at 10 cents	
100 feet bridge superstructure, $50	
500 feet bridge over dam, at $10	
8 pairs lock-gates	2
2 waste-weirs	
Gates at entrance to canal	
Gate-house	
Coffer-dam, &c	1
Alteration of dam at Enfield	
Labor, &c., on dam not included	2
Land damages	2
Engineering and contingencies, 10 per cent	11
Total	1,29

Estimate for second plan.

292,000 cubic yards earth embankment, at 40 cents	$11
66,160 cubic yards rock embankment, at $1.75	11
154,000 cubic yards earth excavation, at 35 cents	5
4,000 cubic yards rock excavation (foundation), at $3	1
8,300 cubic yards rock, channel above dam, at $5	4
7,400 cubic yards rock, channel below dam, at $5	3
5,500 cubic yards rock, channel below canal, at $5	2
1,200 cubic yards clay puddling, at $1.50	
2,904 cubic yards rubble in guard-lock, at $12	3
676 cubic yards cut stone in guard-lock, at $20	1
3,115 cubic yards rubble in first lift-lock, at $12	3
645 cubic yards cut stone in first lift-lock, at $20	1
3,115 cubic yards rubble in second lift-lock, at $12	3
645 cubic yards cut stone in second lift-lock, at $20	1
2,630 cubic yards rubble in third lift-lock, at $12	3
645 cubic yards cut stone in third lift-lock, at $20	1
350 cubic yards rubble in gate-head, at $12	
100 cubic yards cut stone in gate-head, at $16	
200 cubic yards rubble in three waste-weirs, at $12	
40 cubic yards cut stone in three waste-weirs, at $16	
600 cubic yards railroad-bridge abutments, at $12	
200 cubic yards cut stone in railroad-bridge abutments, at $16	
400 cubic yards rubble in road-bridge abutments, at $8	
100 cubic yards cut stone in road-bridge abutments, at $16	
240 cubic yards rubble in foot-bridge abutments, at $8	
60 cubic yards cut stone in foot-bridge abutments, at $16	
450 cubic yards culvert masonry, at $10	
1,630 cubic yards retaining-walls, at $8	1
1,800 cubic yards concrete, at $5	
100 feet bridge superstructure at railroad, at $80	
100 feet bridge superstructure, at $50	
100 feet bridge superstructure, at $25	
8 pairs lock-gates	2
3 waste-weirs	
Gates at entrance to canal	
Gate-house	
Alteration of dam at Enfield	
Coffer-dams, &c	1
Land damages	7
Engineering and contingencies, 10 per cent	7
Total	86

Estimate for third plan (a).

169,800 cubic yards earth excavation, at 35 cents	$5
4,000 cubic yards rock excavation, at $2	
1,550 cubic yards rock excavation (foundations), at $3	
5,500 cubic yards rock, channel below canal, at $5	2
1,972 cubic yards filling for west dam, at $2.50	

cubic yards filling for east dam, at $2.50	$21,685
cubic yards clay puddling, at $1.50	4,500
cubic yards rubble abutments, west dam, at $12	33,600
ıbic yards cut-stone abutments, west dam, at $16	12,800
cubic yards rubble abutments, east dam, at $12	31,200
ıbic yards cut-stone abutments, east dam at $16	6,400
cubic yards rubble in guard-lock, at $12	49,680
ıbic yards cut stone in guard-lock, at $20	12,280
cubic yards rubble in first lift-lock, at $12	37,380
ıbic yards cut stone in first lift-lock, at $20	12,900
cubic yards rubble in second lift-lock, at $12	37,380
ıbic yards cut stone in second lift-lock, at $20	12,900
cubic yards rubble in third lift-lock, at $12	31,560
ıbic yards cut stone in third lift-lock, at $20	12,900
ıbic yards rubble in gate-head, at $12	4,200
ıbic yards cut stone in gate-head, at $16	1,600
ıbic yards rubble in three waste-weirs, at $12	2,400
ıic yards cut stone in three waste-weirs, at $16	640
ıbic yards rubble in railroad-bridge abutments, at $12	7,200
ıbic yards cut stone in railroad-bridge abutments, at $16	3,200
ıbic yards rubble in road-bridge abutments, at $8	3,200
ıbic yards cut stone in road-bridge abutments, at $16	1,600
ıbic yards rubble in foot-bridge abutments, at $8	1,920
ıic yards cut stone in foot-bridge abutments, at $16	960
ıbic yards culvert masonry, at $10	4,500
cubic yards retaining-walls, at $8	12,640
cubic yards concrete, at $5	13,500
0 feet (board measure) timber for west dam, at $45	17,847
00 feet (board measure) timber for east dam, at $45	66,312
pounds iron bolts for west dam, at 10 cents	3,936
0 pounds iron bolts for east dam, at 10 cents	13,760
t of bridge superstructure, at $80	8,000
t of bridge superstructure, at $50	5,000
of lock-gates	22,500
t of bridge superstructure, at $25	2,500
e-weirs	5,200
-houses	1,500
at entrance of new canal	1,500
at entrance of old canal	1,200
tion of Enfield bridge	15,000
-dams, &c	12,000
ay at east dam	1,700
, &c., on west dam, not included	43,000
, &c., on east dam, not included	84,000
damages	90,000
eering and contingencies, 10 per cent	87,419
Total	961,609

Estimate for third plan (b).

) cubic yards earth excavation, at 35 cents	$53,970
ubic yards rock excavation (foundations), at $3	4,575
ubic yards rock, in channel below canal, at $5	27,500
cubic yards rock, filling in dam, at $2.50	48,825
ubic yards clay puddling, at $1.50	3,000
ubic yards rubble in abutments of dam, at $12	50,400
ubic yards cut stone in abutments of dam, at $16	19,200
ubic yards rubble in guard-lock, at $12	69,192
ıic yards cut stone in guard-lock, at $20	13,520
ubic yards rubble in first lift-lock, at $12	37,380
ıic yards cut stone in first lift-lock, at $20	12,900
ubic yards rubble in second lift-lock, at $12	37,380
ıic yards cut stone in second lift-lock, at $20	12,900
ıbic yards rubble in third lift-lock, at $12	31,560
ic yards cut stone in third lift-lock, at $20	12,900
ic yards rubble in gate-head, at $12	4,200
ic yards cut stone in gate-head, at $16	1,600
ic yards rubble in three waste-weirs, at $12	2,400

40 cubic yards cut stone in three waste-weirs, at $16	
600 cubic yards rubble in railroad-bridge abutments, at $12	
200 cubic yards cut stone in railroad-bridge abutments, at $16	
400 cubic yards rubble in road-bridge abutments, at $8	
100 cubic yards cut stone in road-bridge abutments, at $16	
240 cubic yards rubble in foot-bridge abutments, at $8	
60 cubic yards cut stone in foot-bridge abutments, at $16	
450 cubic yards culvert masonry, at $10	
1,580 cubic yards retaining-walls, at $8	1
2,700 cubic yards concrete, at $5	1
2,637,000 feet (board measure) timber in dam, at $45	11
229,380 pounds iron bolts in dam, at 10 cents	2
100 feet bridge superstructure, at $80	
100 feet bridge superstructure, at $50	
100 feet bridge superstructure, at $25	
8 pairs of lock-gates	2
3 waste-weirs	
2 gate-houses	
Gates at entrance to new canal	
Gates at entrance to old canal	
Altering Enfield bridge	1
Coffer-dams, &c	
Fish-way	
Labor, &c., on dam not included	15
Land damages	10
Engineering and contingencies, 10 per cent	9
Total	1,05

Estimate for fourth plan.

33,440 cubic yards earth embankment, at 45 cents	$15
51,792 cubic yards rock embankment, at $2	10
3,125 cubic yards rock excavation (foundations), at $3	
11,000 cubic yards rock in channel at upper dam, $5	5
36,000 cubic yards earth, raising old tow-path, at 45 cents	1
31,500 cubic yards rock, raising old tow-path, at $2	6
2,238 cubic yards filling in upper dam, at $2.50	
4,860 cubic yards filling in lower dam, at $2.20	1
5,500 cubic yards rock, channel below canal, at $5	2
3,000 cubic yards clay pudding, at $1.50	
3,000 cubic yards rubble in upper dam, at $12	1
700 cubic yards cut stone in upper dam, at $16	1
1,800 cubic yards rubble in lower dam, at $12	2
400 cubic yards cut stone in lower dam, at $16	
5,194 cubic yards rubble in upper guard-lock, at $12	6
768 cubic yards cut stone in upper guard-lock, at $20	1
3,702 cubic yards rubble in lower guard-lock, at $12	4
691 cubic yards cut stone in lower guard-lock, at $20	1
2,633 cubic yards rubble in first lift-lock, at $12	3
645 cubic yards cut stone in first lift-lock, at $20	1
3,838 cubic yards rubble in second lift-lock, at $12	4
645 cubic yards cut stone in second lift-lock, at $20	1
2,633 cubic yards rubble in third lift-lock, at $12	3
645 cubic yards cut stone in third lift-lock, at $20	1
350 cubic yards rubble in gate-head, at $12	
100 cubic yards cut stone in gate-head, at $16	
130 cubic yards rubble in two waste-weirs, at $12	
30 cubic yards cut stone in two waste-weirs, at $16	
240 cubic yards rubble in foot-bridge abutments, at $8	
60 cubic yards cut stone in foot-bridge abutments, at $16	
1,350 cubic yards retaining-walls, at $7	1
2,700 cubic yards concrete, at $5	1
519,800 feet (board measure) timber in upper dam, at $45	2
996,200 feet (board measure) timber in lower dam, at $45	4
52,290 pounds iron bolts in upper dam, at 10 cents	
98,880 pounds iron bolts in lower dam, at 10 cents	
100 feet bridge superstructure, at $25	
10 pairs lock-gates	2

2 waste-weirs	$3,500
Gates at entrance to canal	1,500
Gates at entrance to old canal	1,200
Gate-house	750
Coffer-dams, &c	15,000
Fish-ways at dams	2,400
Labor, &c., on upper dam not included	39,000
Labor, &c., on lower dam not included	57,000
Land damages	35,000
Engineering and contingencies, 10 per cent	111,119
Total	1,222,308

Estimate for fifth plan (a).

1,524,300 cubic yards earth excavation, at 30 cents	$457,290
462,000 cubic yards rock excavation, at $1.50	693,000
3,000 cubic yards rock foundation, at $3	9,000
1,200 cubic yards clay pudding, at $1.50	1,800
3,330 cubic yards rubble in guard-lock, at $12	39,960
676 cubic yards cut stone in guard-lock, at $20	13,520
3,120 cubic yards rubble in first lift-lock, at $12	37,440
645 cubic yards cut stone in first lift-lock, at $20	12,900
3,120 cubic yards rubble in second lift-lock, at $12	37,440
645 cubic yards cut stone in second lift-lock, at $20	12,900
2,630 cubic yards rubble in third lift-lock, at $12	31,560
645 cubic yards cut stone in third lift-lock, at $20	12,900
400 cubic yards rubble in four road-bridges, at $8	3,200
225 cubic yards rubble in three foot-bridges, at $8	1,800
8,680 cubic yards rubble in retaining-walls, at $8	69,440
2,700 cubic yards concrete, at $5	13,500
4 road-bridges	6,000
3 foot-bridges	3,000
Removing stop-gates	500
Moving railroad track	1,500
Altering highway	500
8 pairs of lock-gates	22,500
Coffer-dams, &c	5,000
Land damages	155,000
Engineering and contingencies, 10 per cent	164,165
	1,805,815
Add value of old canal	101,750
Total	1,907,565

Estimate for fifth plan (b).

48,000 cubic yards earth excavation (foundations), at 50 cents	$24,000
3,000 cubic yards rock excavation (foundations), at $3	9,000
1,200 cubic yards clay puddling, at $1.50	1,800
3,330 cubic yards rubble in guard-lock, at $12	39,960
676 cubic yards cut stone in guard-lock, at $20	13,520
3,120 cubic yards rubble in first lift-lock, at $12	37,440
645 cubic yards cut stone in first lift-lock, at $20	12,900
3,120 cubic yards rubble in second lift-lock, at $12	37,440
645 cubic yards cut stone in second lift-lock, at $20	12,900
2,630 cubic yards rubble in third lift-lock, at $12	31,560
645 cubic yards cut stone in third lift-lock, at $20	12,900
2,700 cubic yards concrete, at $5	13,500
8 pairs of lock-gates	22,500
Removing stop-gates	500
Coffer-dams, &c	5,000
Engineering and contingencies, 10 per cent	27,492
	302,412
Add value of old canal	101,750
Total	404,162

RECAPITULATION OF ESTIMATES.

First plan:	
Canal and channel on west side	$1,293,868
Second plan:	
Canal on east side	869,636
Third plan (*a*):	
Two dams at island and canal	961,609
Third plan (*b*):	
One dam below island and canal	1,056,071
Fourth plan:	
Two dams at different levels, and canal	1,222,308
Fifth plan (*a*):	
New locks and widening old canal	1,907,565
Fifth plan (*b*):	
New locks only, old canal	404,162

MATERIALS FOR THE WORK.

Earth and rock for the embankments in the first, second, and fourth plans will be easily obtained upon the banks in the vicinity of the work. In the other plans proposed, the cutting will equal the filling or be in excess.

Stone for part of the rubble masonry can probably be obtained of sufficiently good quality in the vicinity.

The cut blocks of freestone for the corners and coping, and the larger blocks of stone for the abutments of the dams, will probably be best obtained from the quarries at East Windsor, about two miles below the foot of the rapids, where blocks of excellent quality and any desired size can be obtained. There are also other quarries at Portland and other places on the river where the stone could likewise be conveniently obtained.

The granite used in the locks would have to be brought from Munson, Massachusetts, or from Westerly, Rhode Island, at both of which places there are excellent quarries. The latter would probably be the best, as there is water communication nearly the whole distance.

The timber for the dams, lock-gates, weirs, &c., can be best obtained in Vermont and New Hampshire, and brought down by railroad directly to where it is to be used. Timber cannot at the present time be rafted down the river past Turner's Falls and Holyoke.

The iron work, both cast and forged, for the locks and dams, can be prepared at Hartford, where there are extensive shops and founderies, and transported by water or rail as is most convenient.

ADVANTAGES AND DISADVANTAGES OF THE PROPOSED IMPROVEMENTS.

Each of the improvements proposed has some especial advantages or disadvantages which it will be well to consider irrespective of the cost.

The first plan proposed, that of a canal on the west side of the river, has the benefit of the channel west of the island to form a large and commodious basin, valuable for various purposes in a canal, but more especially as a safe winter-harbor for the river-boats, where they would not be endangered by the ice in the spring freshets.

It also has the advantage of passing under the railroad-bridge at the most favorable place for width and head-room, and where the company would be required to build a draw, if one should be deemed desirable. This plan leaves the natural channel open for descending boats.

The disadvantages of this plan are that it is upon the outside of the old canal, and nowhere accessible from the shore except by bridges over the old canal. This would be very important to boats loading and unloading at Windsor Locks, or to those lying in the basin west of the island. Also, that the new canal cannot extend to the deep water at the foot of the rapids on account of the great value of the mills and manufacturing operations making use of the water-power of the old canal. The excavated channel below the last lock would be more difficult of navigation than the canal extended down the same distance. This plan furnishes no good landing at Windsor Locks, and little or no additional water-power. It materially diminishes the sectional area of the water-way above the island, even with the proposed width of 150 feet.

The second proposed plan of a canal on the east side of the river has the advantage of being next to the shore, with convenient access to all parts of it. It passes under the railroad, where a draw can be built, if desired, although the whole expense would probably fall on the government. It can extend to the foot of the rapids, and will open into the river on the channel side. It also falls abruptly at the lower end, so that

very short length will be flooded even in the highest water. The entrance will be sily accessible at all stages of the river.
This plan will also provide an abundant water-power, which will be second to none the State, and furnishes an excellent location for manufacturing establishments be-een the canal and river at Warehouse Point.
This plan also leaves the natural channel of the river open for descending boats, and is the only plan that does not touch or interfere in any manner with the old canal.
The disadvantage of this plan, as well as the previous one, is that it materially di-nishes the sectional area of the bed of the river. It also has the disadvantage that, the canal is to be made deeper than proposed, there will be much more rock-cutting the channel above and below Enfield Dam.
The third proposed plan of a dam on each side of the island, and a canal below on e east side, has the advantage of not contracting the water-way above the island, e the two preceding plans. It also shortens the canal on the east side of the river 2.13 miles. In this plan the canal can be wider, if hereafter considered desirable. is plan has also the same advantage regarding water-power as the preceding.
The disadvantages of this plan are: It closes the natural channel of the river, which s been heretofore deemed an important matter. It is open to the objection of the security to which all dams are subject, and their being of far less permanent charac-r and liable to more repairs than a canal.
In this plan also boats endeavoring to enter the upper lock in time of freshets might accidentally carried over the dam.
This plan requires the raising of Enfield bridge, or a draw, which would oblige all ats to pass at one place near the west end of the bridge at ordinary high-water.
The proposed modification of this plan, by making one dam below the island in ace of the two above mentioned, would not materially change its character. It uld have the benefit of shortening the canal to 1.64 miles, but would flow back on e west side of the island so as to interfere with the water-power on Stony Brook, fore mentioned.
The difference between these modifications is chiefly one of cost, if the lower dam is t carried so far down the stream as to endanger the railroad-bridge.
The first modification has some advantage over the second in the depth of water wing over the dams in the highest freshets, which would be 10.1 feet for the first odification, and 11.8 feet for the second.
The fourth proposed plan of one dam near Enfield bridge, and another just below e railroad-bridge, can have the shortest canal of any of the proposed improvements, ing 1.50 miles in length below the lower dam. This, however, would be more than mpensated by the necessity of having one more lock.
This plan can have almost any width of canal desired without materially increasing e cost, but an increase of the proposed depth will make expensive rock-cutting at e upper dam.
It has the disadvantages consequent upon having two dams in the main channel of e river, with their insecurities and repairs, and the risk of boats going over them in eshets.
This plan also gives a less head of water at Warehouse Point by 11 feet, and has no vorable place for manufacturing establishments along its banks.
The greatest disadvantage possessed by this plan, however, is the great depth of ater on the upper dam in time of freshets. This would be 15.2 feet, and would dam e water back in the river above to a height of 3 feet more than is now the case, and uld probably cause some damage above not considered in the estimate.
The lower dam, also, would have upon it, at high-water, 12.4 feet, which is more an would be on the dams in the other plans.
The fifth proposed plan of improving the present canal has all the advantages of the nal on the east side of the river, without contracting the water-way above the and. It also has the advantage of drawing rents from manufactories already estab-bed, using water-power from the canal. It leaves the river-channel open like the er proposed canals, and it could draw all the water from above Enfield Dam, if ired, instead of only a part, as would be the case with either of the other proposed als. It has the advantage, also, that it could be executed part at a time, as the cessities of navigation might require. The locks could be first constructed and the lening done afterward, as might be necessary for larger boats than those now d. Its principal disadvantages are the opposition that the plan would receive from owners of property taken for the widening, and that it would be necessary to pur-se the franchise of the Connecticut River Company, the shares of which would rise alue if it was known that the government desired to purchase it.
he modification of this plan, by making only new locks at present, has only the ntage that if the size of boats hereafter used would not warrant it, the work need be fully carried out, but only such a widening made as is requisite.
this way the original expense would be less, and the final cost perhaps not greater by either of the other plans.

PLANS SELECTED.

A careful consideration of the estimates of cost, with the advantages and disa tages of each of the proposed plans of improvement, will, it is believed, cause t jection of the first plan, the modification of the third plan, the fourth plan, an fifth plan, leaving to be considered the second, third, and modified fifth plans; a these preference is given in the order named.

The contraction of the water-way near Enfield bridge is the only serious objec the second plan, and it is believed that a safe location of the canal can be made

The low dam at the Enfield entrance, which would not be dangerous for bo drawn over accidentally at high-water, is deemed more than an offset to the canal and other advantages of the third plan, with its high dam at the entrance canal.

If the original outlay is to be limited to the smallest amount possible, with a v future enlargements as necessity may require, the modified fifth plan is the one should be selected.

FURTHER IMPROVEMENT OF THE RIVER.

Whatever plan for the improvement of the rapids may be adopted, it should view of further improvements between the foot of the rapids and the city of Har The expense of making a channel of 6 or 7 feet deep will not be much greater one of three or four, which is now the ordinary limit of depth in the channel at the lowest stages of the river. The estimates, therefore, have been made wit in view.

The channel of the river can be so improved as to carry 7 feet of water up as Springfield, Massachusetts, if the amount of traffic would warrant it. In thi vessels navigating Long Island Sound, or even sea-going craft of moderate size, proceed directly to Springfield, and save the transhipment now necessary at Har

All of which, with the accompanying list of maps, tables of approximate disc and list of bench-marks, is respectfully submitted.

THEO. G. ELLIS,
Civil Engi

Major-General G. K. WARREN,
Major United States Engineers.

LIST OF MAPS.

Accompanying this report is a map of Enfield Rapids, on a scale of 400 feet inch, or $\frac{1}{4800}$, showing the several plans of improvement. Also a sheet showi tions across the river, numbered on the maps from 0 to 55.

To show the river above and below the rapids, reference is made to the map Connecticut River from Hartford, Connecticut, to Hadley, Massachusetts, accon ing my report on proposed improvement above Hartford, of March 4, 1871. show the river from Hartford to Long Island Sound, reference is made to th accompanying my report of survey of the Connecticut River below Hartford, uary 11, 1868.

Table of approximate discharge of the Connecticut River at Enfield Rapids, in tenths height, from low to high water at any point.

Height.	Cubic feet per second.	Notes.
.0	4,000	Deduced from observations on slope of water s tions of bed between Hartford and Scantic, b phreys and Abbot formula.
.1	10,500	
.2	20,500	
.3	37,500	
.4	51,000	
.5	61,500	
.6	73,600	
.7	96,000	Interpolated.
.8	118,500	Interpolated.
.9	141,000	Interpolated.
1.0	162,000	From deepest water on Holyoke Dam, Rankine f

Bench-marks—Heights from 0 of Hartford gauge-board.

ON EAST SIDE OF RIVER.

ortheast corner of underpinning stone at northeast corner of red tobacco-shed, near ion 3, 29.81 feet.
ail in south one of two maple trees in front of white house, east of road, near sec- 9, 31.14 feet.
op of southwest corner of abutment of railroad-bridge at Warehouse Point, 61.90

ON WEST SIDE OF RIVER.

op of north one of two hooks in the top of east wall of south lock of old canal, 5 feet.
op of southeast corner of abutment of railroad-bridge, near Windsor Locks, 61.75

op of southeast corner of stone support to bridge over old canal, at north end of path, 50.93 feet.

THE SURVEY FOR A CANAL FROM HARTFORD TO ENFIELD.

he natural sequence to the Enfield Rapids survey, in view of the capabilities of the r above Enfield Dam as far as Holyoke, and the possibility of improving the rapids eans of a canal, was the continuation of the survey for a canal all the way down he navigable water at Hartford.
his was done in the fall and winter of 1873, and the following report was made. map referred to, showing the location of the proposed canal, has been reduced and eferred to the general map of the river herewith presented. The part embraced he report is shown in Plates I and II.

"HARTFORD, CONN., *May* 13, 1873.

ENERAL: According to instructions received, a survey has been made for a canal n the easterly side of the Connecticut River, between Warehouse Point and Hart- l.
his canal is intended to be in continuation of the proposed canal around the Enfield pids reported upon January 10, 1872. Of the plans then presented, the second, or nal from above the rapids to the village of Warehouse Point, on the east side of river, is considered the most feasible, and it is with that view that the present rvey has been made.

THE RIVER BELOW THE RAPIDS.

he channel of the river below the rapids, nearly all the distance to Hartford, is tructed by bars. These exist at the mouth of the Scantic River, 7¼ miles above rtford; opposite Strong's Island, 6¼ miles above; at the mouth of the Farmington er, 5¼ miles above; at Barber's Landing, 3⅞ miles above; and at Higley's Point, 1⅝ es above Hartford.
uring extremely dry seasons this portion of the river has but about 18 inches of ter upon the bars, and is of very difficult navigation. Its general character and nature of the obstructions are detailed in my report upon the improvement of this t of the river, of March 4, 1871.
he fall in the surface at extreme low-water from Warehouse Point to Hartford, a tance of 11 miles, is 6.2 feet. From Warehouse Point to Scantic River, a distance 4 miles, the fall is 1.7 feet, or .49 of a foot to a mile. From Scantic River to Hart- l, a distance of 7¼ miles, the fall is 4.5 feet, or .60 of a foot to a mile.
he fall in the surface of the river, at extreme high-water, from Warehouse Point Hartford, is 3 feet. From Warehouse Point to Scantic River it is .6 foot, or .17 foot mile; from Scantic River to Hartford it is 2.4 feet, or .32 foot to a mile.
he height of the great freshet of 1854 above the zero of the toll-bridge gauge at tford was 29.83 feet, as ascertained and recorded at the time. This is the highest d known.
he zero of the above-named gauge is taken as the base of the levels, and is con- red low-water mark at Hartford, although it is said that in 1858 the water fell 1½ es below it.
he total fall of the river at low-water from above the Enfield Dam to Hartford is feet.

PREVIOUS IMPROVEMENTS MADE AND RECOMMENDED.

uring the summer of 1871 an attempt was made to improve the navigation upon Scantic, Strong's Island, and Farmington River Bars by the construction of wing- s at those places, as proposed in report of March 4 of that year. These works left in an unfinished condition, owing to the failure of the contractor to com- the work within the specified time.

During the next season, 1872, the water of the river continued remarkably high through the whole summer, so as to render it impracticable to determine to what extent the bars have been benefited by the work done.

The extensive improvements around Enfield Rapids which have been proposed would scarcely appear to be warranted, unless the river below could be made navigable for boats of greater draught than at the present time, or the proposed canal continued down to the deep water at Hartford.

The present survey has therefore been made to ascertain the cost of continning the proposed canal around Enfield Rapids down to Hartford.

SURVEY.

The field-work was commenced about the 1st of November, 1872, and was mostly completed by January 1, 1873.

The surveying party consisted of Mr. Charles L. Burdett, civil engineer, principal assistant; Mr. Norman W. Eayrs and Mr. Luther W. Burt, sub-assistants; Oliver Deming, rodman; George W. Newton and Frederick B. Lathrop, chainmen; Wilmot Horton, axman; George V. Wilson and Donald G. Mitchell, flagmen.

A line of survey was run from near the railroad-bridge at Warehouse Point, upon the easterly side of the Connecticut, down to the mouth of the Hockanum River, in East Hartford. The line generally follows the side-hill, which limits the meadow overflowed in freshets. This line is very direct, and uncommonly favorable for such a work.

The route was carefully leveled over, and the levels compared with bench-marks, the heights of which were determined when taking levels from Hartford to Enfield Rapids for the previous surveys.

The total difference of the two lines of levels from the bench-mark on the east abutment of the railroad-bridge at Warehouse Point to the bench-mark on the foundation of house corner of Warwarm avenue and Van Dyke avenue, in Hartford, a distance of about fourteen and one-half miles by the line run, was only .014 foot; and the greatest amount of difference in the comparison of intermediate benches was .030 foot at Scantic River.

At about 500 feet distances apart, taken usually at characteristic points, cross-sections were leveled over to aid in making an approximate location of the canal.

The side-hill along which the survey was made being in many places irregular and quite steep, a very close approximation to a location by the preliminary line was impracticable without consuming time unnecessarily. From a study of the cross-sections a line of approximate location has been placed upon the map accompanying this report, which, it is believed, is nearly upon the best ground. The character of the side-hill is such that in most places a slight alteration of the position of the center line of the canal will greatly affect the amount of work, and a careful location will make a large part of the work only side-hill excavation, or cutting upon one side and embankment upon the other.

The estimated quantities, therefore, of cutting and filling will probably exceed the actual amount required in a final location, and will probably be sufficient to cover all contingencies in the execution of the work.

GENERAL DESCRIPTION OF THE ROUTE.

The previously proposed canal around Enfield Rapids turned into the river at Warehouse Point, reaching the low-water level by means of three locks.

The route at present proposed dispenses with the locks at Warehouse Point, and keeps back from the river-road, leaving the formerly proposed route at the cross-street which passes by the American Hotel and running farther from the bank than the old line, as it is not necessary to reach the river at this place; the object of the change being to keep off the ground covered by freshets. About a mile below Warehouse Point is a rocky point called Red Hill, around which the line passes close to the river. This will probably be the best location, although a perfectly feasible route can be obtained on the flat ground east of the hill. This would necessitate a long cut in which it is probable solid rock will be found. It would, however, be a matter for future determination before a final location should be made. After passing Red Hill, the line follows along the side-hill nearly all the way to the terminus at the Hockanum River in East Hartford. It keeps near the Connecticut River down as far as Prior's Creek, where it diverges to the left and runs at a distance varying from 2,000 to 4,000 feet from it to the lower end. The line is generally outside of the highway up and down the river on the east side, and crosses very few important roads. Those that are crossed are mostly farm-roads to the meadows bordering on the river, which are used only at certain seasons to get in the crops. Narrow swing-bridges at these points that can be left open most of the time, are all that will be required. Some of these roads can be abandoned, or two roads turned over one bridge. The roads that will require heavier and wider bridges are, the main road near Red Hill, the Connecticut River Quarry

ny's Railroad, the road to Bissell's Ferry near the Scantic River, and three roads Hartford. These will all require permanent structures with draws, and will r near the grade of the tow-path of the proposed canal.

few streams of any importance are crossed. The Scantic River is the largest, Podunk River next in size. The others are all small streams. It is proposed r them all under the canal by suitable arches and culverts.

ie lower end of the canal, for about a mile, the line runs across a nearly level v, and out upon a point or spur which reaches nearly to the bank of the Hocka- iver, thereby keeping up the grade of the canal until it reaches the point for ling by locks to the level of the river.

seems to be the most feasible place for entering the Connecticut, although some- elow the most desirable point, opposite Hartford. There appears, however, to oint on the river above which admits of the entrance of the canal.

e the toll-bridge the river channel is shallow and obstructed by bars, and the has no suitable draw, the existing one being only 17 feet in the clear, and not ting order. Below the bridge, where the navigable water begins, the eastern low, and has an extensive shoal extending half across the river. The meadows and overflowed in freshets to a distance of about 4,000 feet from the ordinary ank.

ring the canal across these flats at a high level would be impracticable on ac- f the expense and the contraction of the water-way of the river, and dropping y locks to the level of the meadow would submerge the canal and render its tion impossible whenever there was a high freshet.

point near the Hockanum River, above mentioned, offers a situation protected ie ice and freshets, and gives a good entrance to the canal through the lower the Hockanum.

banks are wooded and well defined, and this stream can be entered in any nav- stage of the Connecticut River.

locks can be placed as near together as is desirable so as to reduce the part of al submerged in freshets to a minimum.

Hockanum is at the present time navigable up to the point where it is pro- o enter it with the canal; but it is proposed to deepen, widen, and straighten nnel out to the Connecticut River, as shown on the map, so as to make a free ce to the canal. This would form a basin where vessels could lie while awaiting ge through the locks, and would afford a safe harbor for wintering, protected he ice.

SLOPE AND AMOUNT OF WATER REQUIRED.

question whether this canal will be for navigation only, or whether the water used for manufacturing purposes also, will materially affect its location and

nclination of the water-surface sufficient only for the waste and lockage is un- dly the best for navigation; the current will be slower, and the amount of water ed to supply the canal and maintain the slope will be a minimum.

is desired to have a sufficient amount of water to supply power for manufactur- rposes, a much greater inclination will have to be given to the surface, which ot be so favorable for navigation on account of the increased current in the canal. so has the disadvantage of requiring a large supply of water at all times to ain the height at the upper end of the canal.

amount of fall required in the whole length, from Enfield to Hartford, for tion only, would be about 1.75 feet; while to carry half the water in the river -water would take about 7 feet fall between the same points. This difference materially alter the position of the best location at the lower end.

here is already a canal upon the west side of the river from Enfield Dam down village of Windsor Locks, which now supplies a valuable and important manu- ng interest, it is very doubtful if more than half the water at low stages of the ould rightfully be diverted to the east side.

ccount of this complication with the franchise of the Connecticut River Com- and the somewhat better location for navigation that can be obtained with the pe, the plan of improvement is made for the purposes of navigation only. If rk should be executed, the location can be made for either navigation alone or additional purpose of a water-power, as may then be thought best.

believed that the cost would not materially differ in the two cases.

amount of water required in the canal for the purposes of navigation will be s follows:

	Cubic feet per second.
tage	200
ation and leakage	168
oration	3
tal	371

This allows a lockful of water every ten minutes, a filtration and leakage of 10 cubic feet per second per mile, and an evaporation of .02 foot in twenty-four hours.

The amount lost by filtration would probably much exceed the above during the first season, but after a certain time the deposit of mud upon the bottom and sides of the canal would greatly diminish the loss from this cause.

The slope assumed for the surface of the water is .00002 of the length, or very nearly 1¼ inches in a mile.

This is a somewhat greater inclination than would be required to supply the quantity of water necessary for navigation, and allows for all contingencies and obstructions in the head of the canal. It would give a mean velocity of about 1.2 feet per second in a straight and smooth channel of the section proposed, or a discharge of 1,620 cubic feet per second. In the proposed canal, however, there will be the usual obstructions to the flow of water, resulting from the accidental irregularities of construction, the abutments and piers for road-bridges that may be placed within the water-line, and especially the resistance offered by aquatic plants. These, with the small loss of head due to curves, will probably reduce the mean velocity to about .75 foot per second, or a discharge of 990 cubic feet per second.

The canal of the Connecticut River Company has been very much obstructed by eel-grass, which grows abundantly upon the sides and bottom—so much so that a special floating steam mowing-machine has been provided to cut it at intervals. An examination of their canal shows that this grass grows to a depth of about 9 feet. The proposed canal being 10 feet deep, it is thought it will not prove so troublesome. Whether this grass is peculiar to the locality, I am not aware.

The slope of the canal has been assumed in excess of the probable requirements of navigation to provide for all contingencies, and if found more than is requisite, the total amount is so small, viz, 1.75 feet in the whole length of the canal from Enfield Dam to East Hartford, that it can be varied to the desired extent by allowing the water to rise at the lower end and fall at the upper, even to becoming level, without damage to the canal.

DIMENSIONS OF THE CANAL.

The length of that part of the canal around Enfield Rapids which is embraced in the present plan is 23,000 feet, or 4.36 miles.

The length, as stated in report of January 10, 1872, was 4.83 miles, but the changes at the lower end and the abandonment of the locks at Warehouse Point, consequent upon the continuation down the river, shorten it about half a mile.

The length of the extension at present proposed, from its junction with the previous survey in the village of Warehouse Point to its entrance into the Hockanum River, is 65,700 feet, or 12.44 miles. About 1,800 feet of this at the lower end is occupied by the locks and intermediate reaches.

The whole length of the canal, from the Enfield Dam to the Hockanum, is therefore 16.80 miles. That portion of the Hockanum River which it is proposed to dredge out is about 2,800 feet in length. This is to be deepened to 8 feet below the lowest water, and to have a bottom width of 150 feet, with slopes of 1½ horizontal to 1 vertical. It is proposed to make the canal 150 feet wide at the water-line and 10 feet deep. The slopes of the excavations and embankments are estimated at 1½ horizontal to 1 vertical. This slope may be somewhat varied in the execution of the work if different materials are encountered than appears upon the surface.

Upon the embankments the tow-path is intended to be 2 feet above the surface of the water and 10 feet wide. In the cuttings a berm of 20 feet is allowed at the tow-path on each side. This is for the purpose of allowing room for ditches and a short space, with a flatter slope than that named above, at the foot of the main slope and at the water's edge.

LOCKS.

The locks of the canal would all be at the lower end, except the guard-lock at the upper end, as proposed for the canal around Enfield Rapids in my previous report.

The total fall from the level of the lower end of the canal to low-water in the river would be 37.5 feet. It is proposed to arrange this in three lifts, the two upper ones to be 11.5 feet each, and the lower one 14.5 feet. This is done so as to make the lifts about equal at the ordinary summer level of the river.

It is intended to make the locks 50 feet wide and 200 feet in length, the same as was proposed for the canal around Enfield Rapids. They are to have 8 feet depth of water upon the miter-sills. This will permit the passage of any boats that would be likely to navigate the Connecticut River above Enfield Rapids.

The masonry of the gate-chambers, quoins, miter-sills, and coping is intended to be of cut granite, with the side walls and backing of coursed rubble, all laid in hydraulic cement and grouted.

The lock-gates are supposed to be of the ordinary construction, with white-oak timbers and pine sheathing, and to be opened and closed by capstans.

BRIDGES.

It is proposed to make the faces of the abutments of the bridges in line with the sides of the bottom of the canal, or 120 feet apart, and to place a circular pier in the middle of the water-way, so as to allow a swing-bridge with clear openings of at least 50 feet on each side of the central pier to span the whole canal. The abutments and piers are intended to be of coursed freestone-rubble, with corners and bridge-seats, having cut beds and builds. The bridges are intended to be of iron; those for the main roads 20 feet wide, and those for the farm-crossings 10 feet wide and correspondingly lighter.

ARCHES AND CULVERTS.

At the crossings of the large streams it is proposed to carry them under the canal through arches, as follows:

At the Scantic River, two 20-foot arches.
At the Podunk River, one 20-foot arch.
At Stoughton's Brook, one 10-foot arch.
At Boyle's Brook, one 10-foot arch.
At Prior's Creek, one 6-foot arch.
At Station 103, one 6-foot arch.

These arches are to have the abutments, wings, and backing of coursed freestone-rubble with cut-stone corners, coping, and arched courses. The smaller streams are carried through the embankment under the canal by box-culverts, varying from 2½ to 5 feet opening.

WASTE-WEIRS AND RETAINING-WALLS.

The masonry of the waste-weirs is to be of rubble with cut corners, similar to that described for the bridge abutments.

The retaining-walls at the ends of the locks, and other places where necessary, are to be built of rubble-masonry.

MATERIALS.

The material encountered in the excavation is mostly a clayey loam, from the village of Warehouse Point down to the Scantic River, a distance of about five miles, after which it becomes more sandy, and for a long distance at the lower end of the route it is almost a pure sand. It is proposed to make the embankments entirely of the material excavated, and to build them up in layers slightly concave, in preference to making puddled walls in the interior, even where the material is entirely sand. The expedient of a central puddled wall in an embankment of porous materials has been shown to be of exceedingly doubtful value, and it is believed that the best modern engineering practice is to make the whole embankment of uniform material in the manner proposed. Canals formed even in very porous ground, like coarse gravel, soon become tight from the deposit of silt from the water. The wastage that might occur from filtration during the first year or more, in a canal constructed as proposed, would be of little importance, as there would be an ample supply of water and a sufficient slope to maintain its depth in the canal.

The stone for all the rubble-masonry can be obtained in the vicinity. The cut blocks of freestone for the corners and coping, and for the voussoirs of the arches, will probably be best obtained from the quarries at East Windsor, where blocks of any desired size and excellent quality can be procured.

The granite used in the locks will have to be brought from Munson, Mass., or Westerly, R. I., at both of which places there are excellent quarries. The latter place is probably the best and easiest of communication.

The timber for the lock-gate, weirs, &c., can be best obtained in Vermont and New Hampshire, and brought down by railroad to where it is to be used. It cannot at the present time be rafted down the river from above Holyoke.

The iron-work for the bridges and locks can be obtained at Springfield and Hartford, where there are extensive works, and transported by water to near where it is to be used on the river.

ALTERATIONS IN THE ENFIELD RAPIDS CANAL.

In my report upon the canal around Enfield Rapids of January 10, 1872, a depth of 6 feet upon the miter-sills of the locks was recommended. This was in view of its extending down only as far as the village of Warehouse Point and entering the river at that place. The depth was thus limited, as it was not thought practicable to improve the natural bed of the river between that point and Hartford so as to maintain more than the above-named depth of water in the channel.

A greater depth in the canal would likewise make a much greater amount of ro excavation at the head of the canal near the Enfield Dam, and also at the foot, wher enters the river at Warehouse Point. If the canal is to be continued to Hartford would recommend that the upper part be made of the same depth as is now propo for the lower part, viz, 8 feet deep upon the miter-sills, and the canal 10 feet de A great part of the previously proposed canal is embanked from the river-bed and sufficiently deep. A little extra work will be required in the cuttings and in the r excavation at the upper end. The rock at the lower end will be avoided. These ad tions will be made to the estimate. There will also be required a little more maso in the guard-lock, and some extra work on the gates, which is also provided for in estimate.

The alterations at the lower end will save some work, which becomes unneces on account of commencing the new canal about half a mile back from the terminus of old survey; viz, the excavation from the point of junction to the river; the rock ex vation in the bed of the river to make a channel from the lower lock out to the ri channel; also the masonry, puddling, and gates in the three locks.

These are deducted in making the total estimates for the whole length of the ca

Estimate from Warehouse Point to Hartford.

1,862,000 cubic yards earth excavation, at 30 cents per yard	$558,
9,430 cubic yards foundation, at 60 cents per yard	5,
98,000 cubic yards dredging in Hockanum River, at 40 cents per yard	39,
2,500 cubic yards clay puddling, at $1.50 per yard	3,
720 cubic yards cut stone in first lock, at $20 per yard	14,
3,830 cubic yards rubble in first lock, at $12 per yard	45,
695 cubic yards cut stone in second lock, at $20 per yard	13,
3,370 cubic yards rubble in second lock, at $12 per yard	40,
695 cubic yards cut stone in third lock, at $20 per yard	13,
3,370 cubic yards rubble in third lock, at $12 per yard	40,
2,555 cubic yards arch-masonry, at $18 per yard	45,
100 cubic yards cut stone in arch abutments, at $16 per yard	1,
4,575 cubic yards rubble in arch abutments, at $12 per yard	54,
280 cubic yards cut stone in bridge abutments, at $16 per yard	4,
2,600 cubic yards rubble in bridge abutments, at $12 per yard	31,
40 cubic yards cut stone in three waste-weirs, at $16 per yard	
200 cubic yards rubble in three waste-weirs, at $12 per yard	2,
3,260 cubic yards culvert-masonry, at $10 per yard	32,
2,500 cubic yards retaining-walls, at $8 per yard	20,
2,700 cubic yards concrete, at $5 per yard	13,
6 pairs lock-gates	19,
3 waste-weirs	1,
Superstructure for 6 swing road-bridges	48,
Superstructure for 6 swing farm-bridges	28,
Coffer-dams, &c	6,
Land damages, twelve and a half miles, at $20,000 per mile	250,
Engineering and contingencies, 10 per cent	133,
Total	1,470,

Additional cost in canal around Enfield Rapids, 10 feet deep and 8 feet on miter-sills of lo

5,500 cubic yards rock excavation above dam, at $5	$27,
17,800 cubic yards rock excavation below dam, at $5	89,
164,000 cubic yards earth excavation, at 35 cents	57,
31 cubic yards cut stone, extra, in guard-lock, at $20	
695 cubic yards rubble, extra, in guard-lock, at $12	8,
Extra on lock-gates	
Total	183,

Amount saved from former estimate for canal around Enfield Rapids by alteration.

2,500 cubic yards earth excavation, at 35 cents	$8,
5,500 cubic yards rock excavation, at $5	27,
1,935 cubic yards cut-stone masonry in locks, at $20	38,
8,860 cubic yards rubble in locks, at $12	106,
1,200 cubic yards retaining-walls, at $8	9,
1,500 cubic yards concrete, at $5	7,
1,200 cubic yards clay puddling, at $1.50	1,
6 pair lock-gates	16,
Total	217,

Total estimate from Enfield Dam to Hartford.

Total cost of canal from Enfield Dam to Warehouse Point	$869,636
Add for increased cost in making it 10 feet deep and 8 feet on miter-sills of locks	183,210
	1,052,846
Less amount saved at lower end	217,045
Revised cost	835,801
Cost of canal from Warehouse Point to Hartford	1,470,544
Total, Enfield Dam to Hartford	2,306,345

List of bench-marks—Heights from 0 of Hartford gauge.

Top of southwest corner of abutment of railroad-bridge at Warehouse Point	61.900
The northwest corner of bridge-seat of southerly abutment of iron bridge over the Scantic River	26.839
Bench-mark cut on large elm-tree on west side of T. Deming's collar-shops, in East Hartford	32.663
Tops of stone foundation at northeast corner of house on southwest corner of Warwarme avenue and Van Dyke avenue, in Hartford	31.540
Zero of gauge-board at Hartford toll-bridge	.000

This report is accompanied by a map of the survey, on two sheets, showing the location of the proposed canal.

Reference is also made to the map of the proposed improvements around Enfield Rapids, and the accompanying report of January 10, 1872.

Respectfully submitted.

THEO. G. ELLIS,
Civil Engineer.

Maj. Gen. G. K. WARREN,
Major United States Engineers."

THE SURVEY OF THE RIVER ABOVE THE RAPIDS.

In the latter part of the summer of 1872 a general survey of the river above Hartford was commenced, with a view of connecting and completing the detached portions already surveyed, and to obtain a full knowledge of the regimen of the river, in order that any further improvement might be made part of a general system which should include that part of the river between Hartford and Holyoke.

This survey was continued during the season of 1873, and in the summer of 1874 a series of experiments upon the flow and volume of discharge was made at Thompsonville, Conn., primarily with a view to determine the volume passing Hartford at different stages, as a series of gauge-readings had been taken there for some years in connection with previous surveys.

The first or partial report of this work was made in July, 1874, as follows:

HARTFORD, CONN., *July* 6, 1874.

GENERAL: In compliance with directions received, I transmit a preliminary report of the survey of the Connecticut River from Hartford to Holyoke.

The survey of the Connecticut River between Hartford and Holyoke was commenced in the latter part of August, 1872, by a small party under Mr. William F. Dyer, civil engineer, who started the field-work at Holyoke and continued down the river to near Chicopee Village. Work was suspended in the latter part of October of that year, and a plot was made of the work then completed.

The survey was resumed early in April, 1873, and two field parties were employed upon the work.

One, under Mr. William F. Dyer, civil engineer, continued the field work down to Enfield Dam; and another, under Mr. Charles L. Burdett, civil engineer, made the surveys from Enfield Dam to Hartford.

The surveys were continued during the season until suspended, about the 1st of October, when the field-work was mostly completed. In October and November borings were made in the bed of the river at several points between Hartford and Holyoke to determine the depth of the rock.

During the past winter the maps and drawings have been completed by Mr. Burdett, Mr. Dyer, Mr. Burnett, and Mr. Curtis.

During the present season observations have been taken by a field party under Mr. Burdett to determine the discharge of the Connecticut and the streams entering into

it between Hartford and Holyoke. These observations are not yet completed, owing to the continued high water. The gauging of the Connecticut has been mainly done at a point just above Thompsonville. Accurate gauging cannot be done at low stages of the river below Enfield Rapids on account of the tides.

METHOD OF MAKING THE SURVEYS.

The method adopted in making this survey has been to run a base-line on each side of the river, and connect all the angles by a system of triangulation. The instruments used were Gurley transits reading to minutes. By repetition, the angles were determined to the nearest 10 seconds.

The shore-lines of the river and the details of the topography were connected by angles and measurements to the base-lines. All side surveys of roads, &c., were made by running transit-lines by angles and distances from the base-lines.

Soundings across the river were taken at intervals of 400 feet, and in the vicinity of bars and shoals at shorter intervals, generally 100 feet, and reduced to the lowest stage of water. These soundings were made from boats rowed directly across the river, keeping in range with poles set upon the banks, generally at right angles to one of the base-lines. The points where these ranges cut the base-lines were accurately fixed, and the boat was rowed as uniformly as possible from shore to shore. The distance of the first sounding from the shore was noted and the intermediate ones were equally spaced. They were taken at equal intervals, measured by a certain number of strokes of the oars, which has been found to give better results than equal intervals of time.

Sections across the whole valley at distances of from 1,200 to 2,000 feet apart were carefully leveled over, all intersections with roads, streams, &c., being noted, and the intervening topography carefully sketched in, with angles to the more prominent objects.

Levels were taken to all the high and low water marks that could be found and were considered reliable, with the date of the freshet.

An attempt was also made to locate the crests of all the bars, by means of micrometer hairs in a transit telescope and a rod used as a telemeter. Whenever there was found a distinct and perceptible crest it has been located upon the maps; but in many cases there appeared to be no distinct continuous crest presenting the characteristic steep slope upon the lower side generally seen in river-bars, giving them rather the character of shoals than proper river-bars, which are formed from the material carried along the bottom by the current. It may be here remarked, that all the bars upon the river below Hartford, as well as those between Enfield Dam and Holyoke, are of the shoal form, and do not present the steep lower side above referred to.

The discharge of the smaller streams running into the Connecticut has been mainly obtained by computing the greatest and least quantities flowing over the dam nearest to the mouth of the stream, together with what is used by the factories. The greatest amounts were most easily obtained, and are the most reliable, as there is generally a good record of the highest point to which the water has risen upon the dam. The least quantity is often indeterminate, as the water is frequently held back and stored in ponds above, so that during a portion of the time no water at all runs in the bed of the stream. The factories then get no water until those above on the same stream are started. In such cases an estimate has been made of the amount of water used by the water-wheels at the lowest stage during running hours, and this quantity taken for the discharge in twenty-four hours. When no other method presented, the best possible estimate was made from the character of the stream. The mean discharge has been mainly obtained from the drainage area of each stream, as nearly as can be ascertained from maps. Five-eighths of the average amount of rain-fall has been taken, as it has been found by comparing the approximate discharge of the Connecticut with the average annual amount of rain-fall that about that proportion passes off through the river.

DESCRIPTION OF THE RIVER.

The river between Hartford and Holyoke can be divided into three characteristic sections:

1st. From Holyoke to Enfield Dam, a distance of 18.4 miles, in which the surface at low-water has a very slight inclination and the water is generally deep and with a slow current.

2d. From Enfield Dam to the foot of Enfield Rapids, a distance of 5¼ miles, in which the water flows over a rocky bed of steep inclination.

3d. From the foot of Enfield Rapids to Hartford, a distance of 10.9 miles, in which the river runs over a sandy bottom through an alluvial formation with an inclination greater than that above Enfield Dam, but still to a certain extent navigable.

At the upper end of the survey the river flows over Holyoke Dam, a substantial

ıre of timber built upon the bed-rock of the river, having an average height of 30 feet.
main body of the dam, which was built in 1849, consists of a cob-work of square s brought up in layers. The timbers lying lengthwise with the current slope pstream at an angle of 2¼ horizontal to 1 vertical; they are laid alternately ıtermediate layers of horizontal timbers across the stream, and the whole is ı solid with stone.
69, the rock in front of the dam having been excavated to a depth of 25 or by the force of the overflow, a cob-work 50 feet wide, forming an apron, was o the dam to strengthen it. It is composed of round timbers 6 feet apart, with rstices filled with stone. The abutments and gates are of good workmanship, not sufficiently high, and are in danger from this cause; the water in 1862 risen above the masonry. Below the dam the river forms a rapid for about 2 own to just below the railroad-bridge at Willimansett; the whole fall being 8 feet.
formerly ascended this rapid to the villages of Holyoke and South Hadley, ı an artificial channel at the lower end, near the west bank, and passed through th Hadley Falls Canal, which has now fallen into ruins, not having been used y years.
iver, over the rapids, runs between high banks and spreads out very little over rs at high-water until it reaches the mouth of Chicopee River. It then over- ıe meadows at high-water, or when it rises to a little more than half the height ame freshets, nearly the whole distance down to a point about 2 miles above sonville. There are contractions of the banks at Chicopee bridge, Springfield, owsic, but for no great distance.
the point about 2 miles above Thompsonville to Enfield Dam, a distance of s, the river is confined between its banks at all stages of the water, and this esents the most available place for gauging the volume of the stream.
ld Dam is a low structure at the head of the rapids, and is open in the middle feet, which was intended originally to allow vessels and fish to pass; but this as been filled in with stone to such an extent as to prevent the passage of boats. he foot of the rapids below Holyoke to Enfield Dam there is good navigation, er 7 feet of water in the channel, except at the flats near the mouth of Chico- er and at Longmeadow Flats, about half-way between Springfield and Thomp- . At the former place there is but 4 feet, and at the latter a little less than t extreme low-water.

e shoals do not appear to have the same formation as the bars in some of the pid portions of the stream, and do not present the sharp and well-defined crest is produced in river-bars by the motion of the sand along the bottom. They be simply flats formed by the widening of the bed of the river between the y banks. This is particularly the case at Longmeadow, where the bed of the low-water is 2,000 feet wide and keeps nearly this width for about a mile.
bed of the stream, from Holyoke Dam down as far as the foot of the rapids Willimansett bridge is mostly rock. From that point to Springfield it is mainly id gravel. For 2 miles below Springfield it has a more muddy character, with of rock cropping out near Pecowsic. From 2 miles below Springfield to near sonville the bottom is again sand and gravel, and from this last point to Enfield ıe bottom is rock.
s this portion of the river between Holyoke and Enfield Dam are the following :
od and iron truss-bridge at Holyoke, for highway, 1,600 feet long, consisting of ns of 160 feet each.
oden truss-bridge between Willimansett and Holyoke, upon the Connecticut Railroad, 750 feet long, with five spans of 150 feet each.
oden truss-bridge at Chicopee, for highway, 1,190 feet long, having seven spans feet each.
on railroad-bridge at Springfield, 1,260 feet long, consisting of seven spans of each.
oden truss-bridge for highway, at Springfield, 1,200 feet long, with six spans of each and three spans of 200 feet each.
bridges are all built upon stone piers; they are but little above the highest nd have no draws.
is a wire-rope ferry at Willimansett, just below Holyoke, and steam-ferries ow Springfield, at Pecowsic, and at Thompsonville.
Holyoke to Chicopee the average width of the river at low-water is about 800

Chicopee to Springfield the average width is about 1,000 feet, and from Spring- *Enfield Dam* the average is about 1,400 feet, at low-water.
freshets the river remains within its banks down to the mouth of the Chico- *then spreads* out over the meadows, overflowing its banks and backing up the

channels of the Chicopee and Westfield Rivers, covering the low land in many places for over a mile in width.

There is at the present time no navigation around Holyoke Dam. Locks of 16 by 80 feet are provided in the canals of the Holyoke Company as far as they are completed, and as this company has assumed the franchise of the old South Hadley Falls Company they would probably extend the locks to the foot of the falls if required by navigation.

The Enfield Rapids extend from Enfield Dam down the river about five and a quarter miles, the stream dividing at one place, about midway of the rapids, into two branches around Ling's Island.

The bed is rough and rocky, and the river runs between high banks. Around these rapids is the canal of the Connecticut River Company, mostly used at the present time as a water-power; but it is provided with locks 19 feet in width and 90 feet between quoins, through which there is still some navigation, although the small size of the locks prevents the passage of such boats as are used for freighting on the lower portion of the river.

There are two bridges over these rapids, one at Enfield, about 950 feet long, extending over the river and canal, in six spans of irregular length. This is an old and dilapidated wooden structure. The other is the iron railway-bridge over the river and canal at Warehouse Point, consisting of one span of 177 feet, twelve spans of 88½ feet, one span of 140 feet, one span of 77 feet, one of 43 feet, and one of 25½ feet; in all, 1,524½ feet.

There is also a flying ferry between Windsor Locks and Warehouse Point. The average width of this part of the river is about 1,100 feet.

For a more particular description of this part of the river, I would respectfully refer to my special report upon the improvement of these rapids, dated January 10, 1872. (See Annual Report for 1872, p. 840.)

From the foot of Enfield Rapids to Hartford the river has a steeper slope than above the dam at Enfield, and has in consequence a somewhat different character. Although it receives a considerable accession of volume from the Scantic and Farmington Rivers, the channel is shoaler and the cross-section smaller than above the rapids, owing to the greater velocity of the current.

The bars also are generally of a different character from those above, presenting a flat slope upstream, and a steep declivity downstream, with a well-defined crest, as usually seen in rivers with a sandy bottom and considerable current.

This part of the river, below Red Hill, nearly opposite the foot of the canal at Windsor Locks, flows wholly through an alluvial formation. The banks appear to be nearly permanent down as far as the mouth of the Scantic River, from which point downward they are washing and caving off to some extent. For about two miles above the railroad-bridge at Hartford they are washing very badly; in some places losing probably 30 or 40 feet in a year.

Between Hartford and the lower end of the canal of the Connecticut River Company at Enfield Rapids there is a navigable channel, with a minimum depth of about 4 feet of water, except upon the bars. There are five bars upon this portion of the river, viz:

Scantic Bar, at the mouth of the Scantic River, seven and a half miles above Hartford, with 2.4 feet of water at the lowest water as the bed of the river now is.

Strong's Island Bar, six and a half miles above Hartford, with 2.5 feet at the lowest water.

Farmington or Tunxis River Bar, five and a half miles above Hartford, with 2.4 feet at the lowest water.

Barber's Landing Bar, three and two-thirds miles above Hartford, with $\frac{8}{10}$ foot of water at the time of the survey in July, 1873. Dredging was done here immediately after, which increased the depth to 2½ feet.

Higley's Point Bar, one and three-quarters miles above Hartford, upon which there are 2.7 feet at the lowest water.

The first three of the above-named bars were improved by the United States Government in the year 1871, by the construction of wing-dams, as shown on the maps. They were built of riprap, and are now in a good state of preservation. In the summer preceding the building of these wing-dams the depth on Scantic Bar was 1.2 feet; on Strong's Island Bar, 1.3 feet, and on Farmington River Bar, 1.5 feet. It will thus be seen that they have materially benefited the channel. At Barber's Landing Bar, in the same season, the depth was one foot, or about what we find it by the present survey. The bed of the river, from the foot of the rapids to Hartford, is sand and gravel. No rock appears at the surface, although in some places it must be quite near it, as shown by the borings. The width of the bed of this portion of the river averages about 1,400 feet. At Hartford the banks are much contracted, being only about 600 feet wide opposite the New York, New Haven and Hartford Railroad freight-house.

At the lowest stages of water, upon this section of the river large sand-banks appear upon the sides of the stream within the bed, so that the width for a great part of the

:e is reduced to about one-half of the width of the bed between the ordinary
In some places it is only 500 or 600 feet.
mes of the highest freshets the water overflows the meadows on either side and
s out in some places to a width of one and a half miles, and has an average
of about one mile. Near the mouth of the Hockanum River there is a very de-
:ontraction of the high-water section, caused by the embankment running to
ry on the west side of the river, the extreme width at this place being 1,900

below Hartford there is a shoal called Hartford Bar, upon which there is a lit-
r 6 feet at extreme low water. This was improved in 1871 by building a wing-
piling about 650 feet long from the west bank, and by dredging in 1871 and
The wing-dam appears to have but little influence upon the depth of water in
nnel, and the effect of the dredging is but temporary; it benefits the channel
or two seasons only. The wing-dam is, however, very important in protecting
ık from washing.
e are two bridges upon this part of the river, both at Hartford. One is the
truss-bridge of the Hartford, Providence and Fishkill Railroad 1,200 feet long,
ven spans of 160 feet each and a draw at the east end with a clear opening of
The other is the Hartford toll-bridge, an old dilapidated wooden truss, in
subsequent additions barely support the original structure. It is 960 feet long,
five spans of 165 feet each, one span of 100 feet, and a draw at the west end of
clear opening. This latter bridge has a causeway leading to it across the
v upon the East Hartford side, with openings to increase the water-way. The
l-bridge has a trestle-work on piling across the overflowed meadows.
t one and one-half miles below the central part of Hartford, at the lower end of
e, is a steam ferry running to the lower part of East Hartford. There is also a
ferry at the mouth of the Scantic River between Windsor and East Windsor.

TIDES.

lower part of the Connecticut River is affected by the tide from Long Island
At Hartford the fluctuations are very irregular, being modified and sometimes
y neutralized by the wind. They are generally perceptible when the water is
5 feet at Hartford.
ie lowest water in summer the tides are more regular and average about 10
in range. The effect of the tides at low-water is not generally noticeable at the
of the Scantic River, seven and one-half miles above Hartford, although very
des at low-water, with a strong southerly wind, are perceptible up to the foot
rapids at Windsor Locks.

THE SLOPE OF THE RIVER.

height of Holyoke Dam at the ends is 97.60 feet above low-water mark at Hart-
l-bridge. The dam is lower at intermediate points, so that at low stages all the
s discharged at, or perhaps below, this level over the central part of the dam.
w-water slope of the surface in the following table commences at the above
as the water flows over the dam.

Low-water slope from Holyoke Dam to Enfield Dam.

Distance in miles.	Fall in feet.	Fall per mile in feet.
.....	29.00	Vertical.
.....	.60	6.000
.....	20.40	68.000
.....	8.90	5.057
.....	.70	.043
.....	59.60	.....

eight of Enfield Dam is irregular and has, as before stated, an opening in the
At the lowest water nearly or quite the whole volume passes through this
at a level of about 38 feet above the Hartford zero. The average level of the
bout one foot higher.

Low-water slope from Enfield Dam to the foot of the rapids.

Distance in miles.	Fall in feet.	Fall per mile in feet.
Dam	2 80	Vertical.
.91	6.40	7.033
1.44	1.40	.972
1.48	17.80	12.027
1.42	3.40	2.394
5.25	31.80	.....

Low-water slope from the foot of Enfield Rapids to Hartford.

Distance in miles.	Fall in feet.	Fall per mile in feet.
3.54	1.70	.480
7.35	4.50	.612
10.89	6.20	.....

The height of low-water at Hartford is zero of the gauge at the toll-bridge, and is the base of all the levels upon this survey. The highest known water above Holyoke Dam was found to be 110.60 feet above the Hartford low-water mark, or 13 feet above the crest of the dam at the ends.

The high-water slope of the river, as determined by levels to the best authenticated high-water marks, is as follows:

High-water slope from Holyoke Dam to Enfield Dam.

Distance in miles.	Fall in feet.	Fall per mile in feet.
Dam	29.	Vertical.
.20	11.10	55.500
1.55	3.30	2.129
1.49	3.90	.869
2.07	—.50	—.242
.55	.50	.909
1.96	3.50	1.837
6.86	5.50	.802
.68	3.80	5.588
18.36	60.20	.....

High-water slope from Enfield Dam to the foot of the rapids.

Distance in miles.	Fall in feet.	Fall per mile in feet.
1.78	8.90	5.000
1.95	8.70	4.462
1.52	.00	.000
5.25	17.60	.....

High-water slope from the foot of Enfield Rapids to Hartford.

Distance in miles.	Fall in feet.	Fall per mile in feet.
3.54	.60	.169
7.35	2.40	.327
10.89	3.00	.....

ater mark at Hartford is the height of the flood of 1854, the highest
ı is taken at 29.80 feet above the zero of the gauge. There are two places
r where the high-water marks appear to give a reverse slope to the sur-
between Chicopee and Springfield, where the upward slope amounts to
about two miles, and the other is at the foot of Enfield Rapids, where
as called level in the previous survey of Enfield Rapids, and is so re-
foregoing tables.
of this apparent anomaly is not determined, the high-water marks being
icated. It is proposed to find others, if possible, to verify or show the
already obtained.

STREAMS FLOWING INTO THE CONNECTICUT.

ream of any size flowing into the Connecticut below Holyoke is the Chic-
which enters on the east side, just above the village of Chicopee. It is
er-power for the manufacturing establishments in the village. Its great-
is 9,635 cubic feet per second; its mean discharge is 1,374 cubic feet per
ast discharge is 669 cubic feet per second.
tream is the Agawam or Westfield River, which enters upon the west side
ngfield. This has many factories upon it in the villages through which
s greatest discharge is 28,633 cubic feet per second; its mean discharge is
et per second; its least discharge is 500 cubic feet per second.
entering from the east, through the lower part of Springfield, is a stream
rtance, and is used as a water-power by the United States armory and
ctories. Its greatest discharge is 899 cubic feet per second; its mean dis-
cubic feet per second; its least discharge is 30 cubic feet per second.
sic Brook, entering the river about one mile below Springfield, on the east
ısed as a water-power for manufacturing purposes. Its greatest discharge
eet per second; its mean discharge is 15 cubic feet per second; its least
12 cubic feet per second
r Brook, entering the river on the east side, through Thompsonville, is
ater-power by the Hartford Carpet Company. Its greatest discharge is
eet per second; its mean discharge is 18 cubic feet per second; its least
9 cubic feet per second.
ook entering the river on the west side, opposite Thompsonville, is also
ıter-power. Its greatest discharge is 200 cubic feet per second; its mean
2 cubic feet per second; its least discharge is 1 cubic foot per second.
ok enters the river on the west side, opposite King's Island, about two
Windsor Locks. It is used for a water-power. Its greatest discharge is
feet per second; it mean discharge is 43 cubic feet per second; its least
20 cubic feet per second.
ver is the next stream of any size. It enters the river seven and one-half
Hartford, on the east side, and has a number of mills upon it. Its greatest
6,116 cubic feet per second; its mean discharge is 139 cubic feet per second;
harge is 35 cubic feet per second.
ington or Tunxis River is a large stream entering the river upon the west
d one-half miles above Hartford. It is used extensively as a water-power
al villages through which it runs, and is quite an important stream. Its
charge is 24,375 cubic feet per second; its mean discharge is 944 cubic feet
its least discharge is 450 cubic feet per second.
ı's Brook, opposite the mouth of the Farmington, is a small stream, used as
er. Its greatest discharge is 143 cubic feet per second; its mean discharge
et per second; its least discharge is 3 cubic feet per second.
nk River enters on the east side, about two miles above Hartford. It is
ater-power by several factories. Its greatest discharge is 342 cubic feet per
mean discharge is 37 cubic feet per second; its least discharge is 8 cubic
ond.
River, which runs through the city of Hartford and enters the Connecti-
vest side, is used as a water-power by mills in Hartford and several places
greatest discharge is 2,308 cubic feet per second; its mean discharge is 139
er second; its least discharge is 25 cubic feet per second.
anum River enters the Connecticut on the east-side at the lower end of the
ut one and one-half miles below Hartford. It is used as a water-power, and
important stream. Its greatest discharge is 6,167 cubic feet per second; its
arge is 132 cubic feet per second; its least discharge is 60 cubic feet per

BORINGS.

vere made at several places, as marked on the maps, to ascertain the depth
in the bed of the river. The tools used were common carpenters' augers

of 1¼ and 2 inches diameter, attached to a rod of ¼-inch gas-pipe. The pipe was in lengths of 8 feet, with threads cut upon the ends, so that they would screw into an ordinary wrought-iron coupling and abut together within it so as to make a firm joint and give an exact length of pipe to serve as a measure of depth. The head of the auger was also fitted with a corresponding thread to screw into the coupling.

A wooden cross-handle was used for turning the auger and pipe from the top. This passed through an eye or socket with a short stem, upon the lower end of which was a screw-thread fitting into the couplings.

The apparatus for withdrawing the auger consisted of a shears, formed of three poles lashed together at the top and provided with blocks for hoisting out the rod. Where the ground was soft these poles were drawn down so as to be forced into the ground, so that a lever was used to withdraw the rod in some cases.

This apparatus worked very well when the auger was withdrawn sufficiently often, but it was difficult to impress the necessity of this upon the assistants, and the apparatus was frequently injured by the sticking of the auger when bored too far to draw easily.

The material bored through was also in some cases very difficult. In many places a quicksand filled up the hole as fast as bored, and in others the material was of great hardness. As it was not thought of sufficient importance to go to the expense of lining the holes with pipe, to prevent filling in, some of the borings were abandoned before reaching the rock. It is believed, however, that they are sufficiently deep to show the character of the river-bed.

Respectfully submitted.

THEO. G. ELLIS,
Civil Engineer.

General G. K. WARREN,
Major of Engineers, U. S. A.

The anomalous rise in the slope of the river, mentioned in the foregoing report, was further investigated by leveling to all the high-water marks that could be found in the vicinity, and no further light was thrown upon the subject. The new marks obtained were either too unreliable to be considered, or agreed substantially with the previous ones already taken. They added nothing to the knowledge of the slope previously obtained.

This report was continued in 1875, embracing the experiments upon the volume and laws of flow at different stages of the river, as follows:

HARTFORD, CONN., *March* 20, 1875.

GENERAL: Having learned from you, on February 6, that the second part of my report upon the survey of the Connecticut River between Hartford and Holyoke, with the maps and drawings therewith submitted, had been destroyed in the train burned between New York and Washington in January last, I have reproduced the same, adding thereto some notes and tables relating to the current observations that it was suggested might be valuable for future reference. The tables relating to the heights and discharge of the river at Hartford have also been brought up to January 1, 1875, in addition to what was before given.

The record of the experiments at Thompsonville is made quite complete, embracing the velocities observed, the computed areas, widths, slopes, and heights of the water, as determined by the survey, in order that, although somewhat incomplete in themselves, they may be preserved for reference and comparison with other observations taken elsewhere.

The results are given in tabular form, so that they can be readily plotted upon section-paper.

The main object of the survey having been the determination of the character of the river-bed, and the volume of the discharge at Hartford having been only an incidental part of the operations, must account for any deficiencies in the hydraulic observations as a matter of scientific inquiry.

GAUGING THE RIVER.

In connection with the improvement of the Connecticut River for the past three years, the height of the water has been taken daily at Hartford by the gauge at the toll-bridge, the zero of which, or low-water mark, at Hartford, has been taken as the base for the levels of the Connecticut River surveys.

In order to determine the discharge from these readings, the gauging of the river at some point as near as practicable to Hartford became necessary. At and below this place the rise and fall of the tide is such as to prevent accurate measurements of volume, except at high stages of the river. The effect of the tide is felt at times as far as the foot of Enfield Rapids, so that it was necessary to take a point farther up the river for the determination of the discharge.

No locality favorable for gauging operations presenting itself below Enfield Dam, a

for the same height of water, and be less subject to variations of quantity at ne stage of the river than would ordinarily be the case if the stream did not rge so freely below. The wide channel and the slow current for some miles also favors this position, acting as an equalizing reservoir to give a regular dis-, and to free the part of the river chosen for experiments from pulsations. It e observed also from the plate of sections submitted that the part of the chan-er which floats were run is of nearly uniform area and form of cross-section, a very favorable locality for float experiments, where they can be passed very o the bottom without touching.

w the main position chosen for the float-observations, two other sections were : one across the smallest sectional area, about 1,600 feet below, where the bottom y, and another where the bed again deepens near the Thompsonville Ferry. sections are marked B and C, respectively, on the map.

he upper or principal position, seven parallel sections, 50 feet apart, were taken the river-bed as nearly as possible at right angles to the current. The sound-ere accurately made with a chain, and located by angles from the shore. The d adopted was substantially that described in the report of the survey of the sippi River by Humphreys and Abbot. The boat carrying the sounding-chain opped slowly down the stream, and, at the moment of crossing, the section was ed by an observer stationed with his telescope upon the line. The chain was ropped, and the angle taken to it by a second observer on the shore. All the ns were carefully sounded in this manner, so as to give as nearly as possible the form of the bottom.

seven sections across the river at the upper or main position covered a distance feet, only 200 feet of which was used at one time for the float-observations. oats were first run over the five lower lines, embracing the lower 200 feet, as the was high, and the base of this part was above the highest water likely to occur. e water fell, however, the floats were run over the upper 200 feet, which pre-l a little more uniform bottom than is found at the two lower section-lines. The of these positions is called F, and the upper one G, on the maps. The observa-by current-meter were in all cases taken upon the middle section, over which were run.

he two lower positions, marked B and C on the map, only one line of soundings aken at each place in the manner before described, and on these sections the rations were all taken with a current-meter. The general survey, as shown on aps, gives the form of the bottom above and below these sections with sufficient acy, and shows that it is nearly uniform for some distance above and below the observations were taken. These surveys and the subsequent gaugings were de by Mr. Charles L. Burdett, civil engineer, and party of four, who have also been yed part of the time upon other surveys and work in connection with the im-ment of the Connecticut River below Hartford.

THE APPARATUS USED.

herent defect of registering the force of the current only at a given instant of time, rendering it difficult to obtain the mean velocity for any required period.

The first two seem to be the only instruments that have been used to obtain the mean velocity of a large river with any considerable degree of accuracy; and it is to these only that attention has been given in gauging the Connecticut.

Each of the two methods of measuring velocities, with the double floats and the current-meter, has its peculiar advantages and defects, which it is well to consider, with a view to avoid, if possible, errors incident to the use of either that experience has shown to exist.

Double floats, all things considered, have proved to be the most reliable means of measuring subsurface velocities where a sufficiently uniform channel can be found in which to use them. The apparatus is cheap and simple, and the results apparent, admitting of no unperceived large error. It can be used at all velocities, measuring accurately even the smallest currents; and the best experiments and data known in river hydraulics have been made with it.

The errors and uncertainties of this system, as generally used, appear to be:

The resistance of the surface-float and connecting cord, and their influence upon the velocity of the lower float.

The small sinking-weight of the lower float, and consequent slight tension that can be obtained upon the connecting cord, without a too great increase in the size of the upper float. This weight must be sufficient to prevent the lower float from drifting upward in whirls and eddies, and the cord from being drifted out of line by intermediate currents of different velocities, otherwise we cannot know the depths at which the lower float runs.

The tipping of the lower float forward, or backward, by the draught of the upper float and cord, which alters its horizontal resistance, and increases the liability to be carried upward in eddies; as the annular lower float then presents a greater surface to the upward current.

The uncertainty of the position of the lower float, with respect to the upper or observed float.

The fact that the submerged float measures the velocity of only one point in the stream, which may be at the maximum or minimum of the usual variations and impulses.

And, lastly, the lower float cannot be run close to the bottom, except in regular channels; the depth of the float being limited by any irregularity in the depth of the stream.

Most of the above-named uncertainties, however, can be avoided with proper apparatus in a regular channel.

The advantages of the method of measuring the velocity with a current-meter are:

The observations can be taken all on one section, and do not require a continuous, regular channel.

They can be taken more rapidly than floats.

They average the variations of velocity during the time of the observations.

They can be taken close to the bottom.

This method also admits of a rapid and easy way of obtaining the mean velocity in any vertical plane by one observation.

The principal defects of this system of measuring velocities are as follows:

The current-meter is difficult to rate with the exactness required for accurate observations; unless correctly rated by an experienced and competent observer, and unless the wheel is of a form not liable to have its rate affected by slight accidents, the instrument has little or no scientific or practical value.

The resistance and friction is irregular in water containing sediment.

Low velocities cannot be registered, and the movement of the wheel becomes irregular before actual stoppage occurs.

The indexes only register full revolutions which may be of several feet pitch.

Floating substances, such as leaves and straws, are liable to catch upon the wheel and impede its action.

Vertical and propeller wheels do not take the exact direction of the current, but stand a little off to one side, on account of the head pressure, until the tail is turned so as to have a sufficient lateral pressure or resistance to maintain its position.

In deep water there is considerable difficulty in connecting and disconnecting the register at the exact time desired.

In addition to the above a great many current-meters are of faulty construction, so that they have been regarded by many eminent hydraulic engineers rather as pretty toys than as scientific instruments. Some of the more common errors of construction are: Making the gearing of the register shut on to the worm of the wheel-shaft by a positive motion; using differential wheels on the same worm, which is liable to split two teeth apart which should remain together, and thus vitiate the reading of the index by one whole turn of the lesser wheel; and making the vanes of the measuring-wheel exposed in such a way that they can be bent or have their angle changed by any

slight accident or pressure. It is believed, however, that with proper construction current-meters are very valuable instruments for determining the subsurface velocities of rivers, and in many cases are the most accurate and expeditious means of gauging streams. The advantages and defects of each of these two methods of measuring velocities have been carefully considered, and an effort has been made to use each of them in the best manner practicable, and to avoid, as far as possible, the objections that have been made to them.

In the gauging of the Connecticut at Thompsonville, both floats and meters have been used with satisfactory results; and as the apparatus differs somewhat from the more common forms, a short description will be given of it.

The requisites of a good double-float are conceived to be as follows:

The subsurface-float must have as great lateral resistance as practicable, and it must be equal in all directions, on account of the rotation of the float. It must have a very small vertical resistance, to prevent its being lifted by rising currents, or drawing down the surface-float by downward currents. It must have sufficient stability of flotation in itself to always stand upright when in the water. It must not be drawn out of a vertical position, by the cord to the surface-float. It must have a sufficient preponderance of weight to prevent its floating upward in eddies, and to keep the connecting-cord practically vertical, but not to increase the size of the surface-float beyond what is absolutely necessary for this purpose.

The surface-float should be as light as possible, proportionally to its volume. It should be as small as practicable, and sustain the required weight of the subsurface-float, and its form must be such as to offer a minimum of resistance to motion from both the water and wind.

The connecting-cord should be the smallest that can be obtained with the requisite strength and flexibility.

The subsurface-float adopted for experiments upon the currents in the Connecticut River was a hollow annulus of tin 8½ inches high, 8½ inches outside diameter, and 7½ inches inside diameter, leaving a cylindrical ring of ½ inch in thickness and 8½ inches in height.

Two brass wires were soldered across the bottom, at right angles to each other, and two others inside, half-way to the top, so that their intersection was at the center of figure of the float. These floats required about 20 ounces of lead to just sink them, and they were further loaded with 8 ounces preponderance. This weight was placed upon the lower cross-wires and firmly secured, being about 4 inches below the center of flotation, which gave the whole float sufficient stability. The extra 8 ounces would give, when submerged, 7.3 ounces tension upon the cord; but, with the wire used in attaching the weight, it was found to be 8 ounces when measured in the water.

The suspending cord was attached to the float at the middle cross-wires, so that there should be no tendency to tip the float when the cord was not vertical.

The surface-floats were tin ellipsoids, of 6 inches diameter and 1½ inches in thickness. They were fitted with a cork on top for holding a small wire and flag, and at the bottom they were furnished with an eye for the cord. The flotation-power of these ellipsoids was about 11 ounces in addition to their own weight of 4 ounces.

The diameter of the connecting-rod was .036 of an inch.

Two current-meters have been used at different times.

The first was a propeller-meter, an improved Waltman tachometer, made by Secretan, of Paris, France, about 18 inches long, with a screw-propeller wheel 3½ inches in diameter and about 5 inches pitch. The wheel turns a horizontal axis, provided with a worm, which gears into a toothed wheel indicating 100 revolutions; which latter, by means of a pinion on its axis, turns another wheel which indicates hundreds up to 1,000 revolutions. These wheels are carried in a frame which moves them off and on to the worm alternately, by pulling upward upon a cord attached to a lever which recoils by means of a spring. When first purchased some years ago this instrument moved the registering wheel *on* to the worm by a cam, or positive motion, and *off* by a spring. This is the usual construction, but is very faulty; as the point of a tooth of the wheel sometimes strikes upon the edge of the thread of the worm, which not only stops the wheel from revolving, but when under water, where the force of the pull upon the cord cannot be graduated nor the effect seen, the gearing is soon seriously damaged. This defect was remedied by making the frame carrying the register to push *off* from the worm by a cam and press *on* to it by means of a spring.

This meter was carefully rated in 1870, and again tested in June, 1874, when its rate was found to remain unchanged.

The rating was done in the following manner: A 16-feet Whitehall boat was fitted with a hinged frame or bowsprit extending out a little more than 5 feet from the bow of the boat. At the outer end a piece of gas-pipe, three-fourths of an inch in diameter, passed through it vertically into the water and was held in place by a key. Upon the lower end of this pipe the instrument was fixed so as to rotate freely. The whole apparatus could turn upward and over into the boat for adjustment and reading the indexes. The meter was thus suspended about 5 feet in front of the boat, and 1 foot

or more below the keel. By placing floating objects in the water and fixing the hair of a telescope upon them while the boat approached, this position was found to be beyond the influence of the pushing effect of the boat upon the water. A base line 200 feet long was measured upon the shore, and right angles established at the ends by means of flag-poles, forming ranges 200 feet apart. Through this distance the boat was drawn by a line from the shore at uniform rates of speed from about four-tenths of a foot a second to 9 feet per second, and the number of revolutions and the time between the two ranges noted. These observations were reduced to the number of revolutions per second and the number of feet per second and plotted as co-ordinates upon section-paper. A mean line was then drawn through these points, and a formula computed. It was found that between the limits of .7 of a foot and 9 feet the number of feet per second was exactly five-thirteenths of the number of revolutions per second plus .25.

If f = number of feet per second, and n = number of revolutions per second, then—

$$f = \tfrac{5}{13} n + .25 \qquad (1)$$

As in this form of meter n, or $\frac{N}{t}$, when N represents the total number of revolutions in t seconds, is a variable quantity requiring some time and trouble to compute for a large number of observations, it becomes desirable to put this expression in a form more easy of computation. This is done by multiplying the above equation (1) by 100, and dividing the fraction. We then have:

$$100 f = 38.5 n + 25 \qquad (2)$$

It will be observed that 38.5 n will be the number of revolutions in 38½ seconds. If, therefore, we run the meter 38½ seconds, add 25 to the number of revolutions shown on the dial, and point off two places of decimals, it will give the feet per second. This was generally done, and the result set down at once opposite the number of revolutions. This meter has a very short pitch and quick motion, so that the number of revolutions is always greater than the number of seconds. If the observation be continued a certain number of seconds the inaccuracy of recording only whole revolutions is very small. This meter was used chiefly with the higher velocities, as it ceased to register accurately, and in exact conformity with the formula, below seven-tenths of a foot per second.

The second current-meter used was one constructed especially to avoid some of the difficulties usually encountered with such instruments. It was desired to get less friction, so as to measure low velocities, to avoid catching floating substances, such as leaves, grass, &c., and to eliminate the error consequent upon not standing exactly in the line of the current.

In order to have as little friction as possible, the apparatus was made to record by breaks in an electric circuit, and the train of wheels was dispensed with.* The measuring-wheel was made to run horizontally, so as to support its weight by the end-friction of one of the bearings. This horizontal position also eliminated the error of direction, as the frame could stand at any angle to the stream without affecting the results. To avoid catching floating objects, a peculiar form of wheel and supporting-frame was adopted. Each vane of the wheel consisted of a hollow, conical end, with two tangential planes joining it to the axis, so that each arm or vane presented a sharp edge on the back, and an open, flaring face. The central hub was made tapering towards the ends, and the ends of the supporting frame were partially inclosed within it, so that any object striking the axis could slide off easily.

Upon one arm of the frame which carries the wheel, an insulated wire was passed through eyes and a hard-rubber box to near the hub of the wheel, when it ended in a coil of fine platinum wire. This came in contact at each revolution with a loop of platinum wire on the hub, and formed the connection and break in the circuit. The central bearings and tail of the machine were of ordinary construction, except that provision was made to turn the wheel vertical for measuring close to a vertical wall, as in a canal, when desired, or at any required angle.

The registering apparatus of this meter consisted of an electro-magnet, the armature of which was connected by a lever with the escapement of a train of clock-work, driven by a spring. This had all the adjustments usual in telegraphic sounders. The train was provided with three dials recording units, hundreds, and thousands, up to 10,000.

This register was arranged in a box and provided with a switch to connect or disconnect the current. The dials were read through a glass in the top; the handle to the switch and the screw-sockets for the connecting wires being outside of the box.

The Grenet battery was chosen for these experiments, mainly on account of the form of the jar being so suitable for use in a boat without danger of spilling the contained

* A telegraphic current-meter was first used by D. Farrand Henry, esq., civil engineer, of Detroit, upon the United States lake survey, and to whom the writer is much indebted for valuable suggestions in the use of the instrument. A full description of Mr. Henry's meter will be found in the Journal of the Franklin Institute, volume LXI.

fluid. In practice it proved all that could be desired. The facility with which the power can be regulated by the greater or less immersion of the zinc plate is one of its chief advantages in such experiments; and the absence of all fumes avoids injury to the apparatus and inconvenience to the observers. The jar used was of about 32 fluid ounces capacity. It was charged with a fluid composed of 3 ounces of bichromate of potassa, 3 ounces of sulphuric acid, and 24 ounces of water.

This battery was fitted in a box, to the top of which was attached the register, connected by the proper wires. When transported the plates of the battery were taken out of the jar and placed in a separate receptacle in the box. This is easily done, as they are attached to the brass cover of the jar. When closed up, the whole apparatus was 7 by 11 by 12 inches in size, and was easily carried by means of a leather-strap handle.

Connecting with the meter were one insulated wire and one fine plain copper wire. The plain wire was wound around the insulated wire in long turns, so as to form one cord with it, and the whole was wound upon a reel. The inner end upon the reel was brought outwards, and the two wires attached to the battery and register by screw-sockets upon the boxes. The other ends were attached to the meter. The insulated wire was hooked to a similar piece of wire carried along one of the arms to the wheel, and the other was fastened into a socket in the frame by means of a set-screw. The joint in the insulated wire was covered with a piece of small rubber tube.

This current-meter was carefully tested and rated in June, 1874, at the same place and in the same manner as the first one, except that it did not require to be taken from the water to read the number of revolutions, which were registered on the dials in the boat. The observations were reduced to the number of revolutions per second, and to the feet per second, and plotted upon section-paper as before described. A line was then drawn through these points and the formula for the rate ascertained to be as follows:

f = the number of feet per second.
n = the number of revolutions per second.
N = the total number of revolutions.
t = the total time in seconds.

$$f = \frac{200}{53} n + .02 \qquad (1)$$

This can be put in a more convenient form for computation, as follows:

$$n = \frac{N}{t}; \text{ then } f = \frac{200}{53} \times \frac{N}{t} + .02$$

If we run the meter 53 revolutions, and note the time t', we shall have—

$$f = 200 \times \frac{1}{t'} + .02 \qquad (2)$$

This value of f is easily found by taking the reciprocal of t' from the table of reciprocals usually found with tables of squares and cubes, multiply by 200 and add .02, which is a very simple operation.

This formula is made to depend upon the number of seconds in a complete number of revolutions, rather than the number of revolutions in a certain number of seconds, as with the previously described meter, because of the long pitch of the wheel, which will be seen from the first formula above to be about one turn in 4 feet. This would require a very long observation to insure accuracy, if the number of revolutions were taken in a fixed time.

At a velocity of 1 foot per second, one revolution of the wheel takes about four seconds. We should therefore be obliged to continue the observation four times as long to get the same accuracy if we took the number of revolutions in a given number of seconds as we should if we took the number of seconds in a given number of revolutions.

With the other current-meter the case is just the reverse. The pitch of the screw is short, making at a velocity of 1 foot per second about two and a half revolutions per second, and more at higher velocities. Greater accuracy in this case is therefore obtained by taking the number of revolutions in a certain number of seconds, and the formula is arranged accordingly.

The observations with the current-meters were made from an anchored boat. This boat was provided with a spring plank secured to one of the forward thwarts and passed over a frame resting upon another thwart about amidships, so that the end would reach a little over the stern. At the end of this plank was a pulley over which the standing-line, upon which the meter was run up and down, was passed and then secured to a cleat on the plank.

This line was anchored at the bottom by a cast-iron wheel, weighing about forty pounds, which lay flat on the bottom of the river and allowed the meter to descend close to it. The line was drawn tight, so as to spring the plank somewhat and bring

a sufficient strain on it to prevent too much sag down stream by the current. The motion of the boat was taken up by the play of the plank, so as not to disturb the line. The meter was raised and lowered upon this standing-line by a fine chain marked to feet, which passed over a smaller pulley near the end of the plank on the under side, and by which the depth of the water was always correctly known.

The instrument was placed upon a piece of lead pipe about 15 inches long, corresponding in size with the pipe upon which it was rated, and through which the standing-line was passed. At the bottom of this lead pipe was a circular disk of lead to give sufficient sinking force, the whole weighing 3½ pounds; the hoisting-chain was attached to the upper end of the lead pipe, the first foot-mark of the chain being 1 foot above the center of the meter-wheel. This arrangement was adopted after considerable previous experience in using these meters, and has proved very convenient and easily managed. Wire and wire cord were tried for the standing-line, but they are unfit for numerous experiments in rivers, unless of great depth and strength of current, from their want of flexibility, and from their kinking and breaking when secured to the boat.

With the Secretan current-meter a fine line of .023 of an inch diameter was used to connect and disconnect the register. When the electric apparatus was used, the connecting-wire was allowed to drift down stream while the instrument was in use, enough being let out to allow the meter to reach the bottom; it could then be raised or lowered to any position and read without disturbing the wire or register. This latter was placed in the stern of the boat, where it could be readily seen and heard.

THE METHOD OF GAUGING.

In gauging the river at Thompsonville, the greater part of the observations were made in vertical planes, from the surface to the bottom, taking the velocity at every foot in depth. These planes were taken as near as practicable at 100 feet distances across the river.

The floats were run as near the bottom as possible, generally increasing the depth until the lower float grounded on some part of its course. In the middle portion of the river, the great uniformity of depth at the place where the observations were made permitted the floats to run quite near to the bottom; but near the banks, where the slope was encountered, the current would rarely follow a uniform depth, but would drift the floats against the bottom at some part of their course, making it impracticable to obtain the bottom velocity with exactness in this portion of the river.

The floats were started on ranges so as to take each vertical series of subsurface velocities as nearly as possible in the same vertical plane, at a given distance from the base. They varied somewhat from the same exact course, owing to slight variations in the direction of the current at different times and at different depths; but all the distances out were taken by angles at the upper and lower sections across the river, and the mean distance out has been taken for the position of the vertical plane of velocities.

When the velocities were measured with the current-meter they were likewise taken at about 100 feet intervals across the river, and at each foot in depth to the bottom. The lowest observation in each vertical series was generally about four-tenths of a foot from the bottom. The meter was lowered until the lead disk touched the anchor-weight lying on the bottom, which was the lowest practicable depth that could be observed.

At each point of observation the position of the standing-line upon which the meter was run was fixed by angles from the shore.

In all parts of the river the meter observations could be taken much nearer the bottom than the floats, and this was particularly the case near the banks. For this reason the majority of the vertical curves of velocities were taken with the current-meter.

A number of mid-depth velocities at 100 feet apart across the river were taken with floats at different times to determine the discharge. Two observations were usually taken at each point, and the average used as the true mid-depth velocity. These mid-depth gaugings were in all cases made with double floats, such as have been previously described. The method of observing and determining the path of the floats was essentially that described in the report upon the Mississippi River. A base of 200 feet in length was taken as being, perhaps, the most convenient length, except in one case at the lowest water and a mean velocity of .34 of a foot per second, when a line of mid-depth velocities was taken with a base of 100 feet, on account of the great length of time taken by the floats in passing over 200 feet.

The instruments were set up at each end of the base, the signals were given, and the angles to the floats taken as described by Humphreys and Abbot in their report upon the Mississippi, except that both observers read the time. This appeared to be the best plan in practice. Errors in reading and failures to get the reading at all will sometimes occur, and this method checks the results. Most of the intervals of time

d by the two observers agreed; but often the time would differ by one second, ıetimes by two. In reading to the nearest second only, as was ordinarily done e float observations, each observer may be nearly or quite half a second out at ıding, so that the difference may be nearly a second in error; and the time of ırver may be too great and the other too small by this amount, even without allowance for the personal errors of the difference of time taken in looking telescope to the watch, or in giving signals at exactly the right instant. The time of the two observers is probably much more exact, and has been used in putations. A trial was made with electric signals, but without a third observer, the time directly from the signals, no greater precision was obtained. The erved, however, is sufficiently accurate, as the fluctuations and impulses in the render greater precision unimportant.

GAUGING AT OTHER PLACES.

lition to the gauging of the river at Thompsonville in the present survey, ve been some previous measurements taken in connection with the improve- the river which are valuable in determining the discharge.

gangings were made at Hartford Bar in 1871, in which the velocities were meas- half depths with a Woltmann current-meter of large size, and carefully rated, discharges computed by the Humphreys and Abbot methods.

ngs were also made in April, 1872, and January, 1874, at Dividend Bar, just Rocky Hill, or about nine miles below Hartford. These measurements were th double floats, taken at the average mid-depth. The mean section of the s divided into divisions, and the average in each division taken for the velocity division. The discharge was then computed by the Humphreys and Abbot th formula. The bed of the river at this place is very favorable for mid-depth with floats, being steep at the banks and flat on the bottom for nearly the idth of the stream. It can only be used at high-water, however, owing to the f the tides when the water is at the lower stages.

gaugings at Dividend Bar were made at the height of the two highest freshets e record of the height of water was commenced, in February, 1871. That January, 1874, when the height at Hartford was 23.87 feet above low-water, is est measurement actually made of the discharge of the river. The rise of the s carefully watched each year, and as soon as the water attained its maximum t Hartford, operations were commenced at Dividend Bar, so as to obtain the e when the water was at its greatest height at that place. In this way the vol- responding to the height at Hartford was accurately obtained by direct measure- xcept the increase from the entrance of small streams between the two points.

ver has also been gauged by observing the heights of water at Holyoke Dam. ntity of discharge, in the absence of any direct experiments upon this particu- of dam, has been computed by Francis formula, without end contraction, of $3\,k\,l\,\frac{1}{2}$, as being the best known.

lam is 1,017 feet long on the crest. It has a slope back from the crest of about ontal to 1 vertical, and an apron in front with a slope of about 2 to 1.

lope above the crest of the dam would probably have the effect of increasing harge, by diminishing the bottom contraction of the vein, and the slope of the elow the crest would probably have the contrary effect of diminishing the flow, esistance it offers to the free discharge of the water after it passes the crest. ffects would be small compared with the whole quantity discharged, and it is l that they would nearly balance each other.

s were taken along the crest of the dam and compared with the company's pon the south abutment near the gate-house.

ord of the height of the water has been kept here at times by the Holyoke Power Company, copies of which at various times have been obtained through dness of the late Mr. Stewart S. Chase, the company's engineer, and of Mr. A. Chase, his successor.

MECHANICAL DETERMINATION OF MEAN VELOCITY.

g the observation at Thompsonville of the velocities of the currents in verti- es with the current-meter, an additional observation was taken at the end of tical series to determine the mean velocity of the section at one operation, by cally integrating from the surface to the bottom.

as done in the following manner: The meter was started at the surface, its ading and the time being noted, and passed slowly down the standing-cord by the chain a certain distance per second, until it reached the bottom, when it ediately drawn up at the same rate to the surface, when its index-reading ang were again noted. The uniformity of motion in descending and ascendind

were assured by one assistant counting the intervals of time for each foot, while another lowered the chain and saw the successive foot-marks enter the water. Equal spaces being passed over in equal times, the varying velocities passed through were mechanically averaged, so that the feet per second deduced from the index-reading and the time of the observation would give the mean velocity of the section. These observations were taken as a check upon the others, not expecting that the results would agree so nearly with the actual mean of the velocities at the successive depths as has been found from the computed results. These show a remarkable agreement, considering that the integrating observations occupied but a very short time, generally two or three minutes, an interval of time only sufficient to eliminate errors of observation in noting the number of seconds or reading the index. The time was not generally sufficient to average the impulses in the current.

The following examples of actual means of each foot in depth and the means found by one observation are given to show the results of two series of sections across the river. In some cases the means of all the sections by the two methods were alike to the nearest hundredth of a foot.

Section at G, meter No. 2.			Section at C, meter No. 1.		
Depth.	Mean of all at each foot.	Mean by integrating.	Depth.	Mean of all at each foot.	Mean by integrating.
16.6	.43	.50	6.2	.49	.46
17.5	.78	.83	12.8	.93	.91
16.5	1.12	1.07	19.3	1.91	1.88
15.5	1.11	1.12	22.3	2.51	2.46
14.3	1.21	1.23	20.8	2.71	2.70
13.7	1.26	1.25	19.7	2.58	2.57
11.2	1.03	.99	19.7	2.17	2.13
8.4	.94	.94	17.4	1.92	1.89
5.8	.68	.67	15.6	1.45	1.49
			18.1	1.40	1.44
Sum.....	8.56	8.60	8.3	.90	.93
			5.2	.73	.75
Mean.....	.951	.956	Sum.....	19.70	19.61
			Mean.....	1.642	1.634

It will be seen from the close agreement of these quantities that this presents a very rapid and accurate method of gauging streams whose bottom velocity is not too small to be registered by the current-meter. One operation at each point located on a cross-section of the stream by measurement, or by an angle from the shore, gives both the depth and mean velocity at the same time. The discharge can be readily computed by Simpson's rule applied to the rectangles of the mean velocities by the depths, if the intervals between the sections are equal. If they are unequal, as will usually be the case in rivers, the volume can be obtained by multiplying the mean area of each two such rectangles by the distance between them in feet, and adding the results for the several divisions together to obtain the total discharge. This gives the number of cubic feet passing the section in one second. The method of averaging end areas gives a slightly too great volume when the bounding-lines of the prismoids are straight, but the outward curve of the bottom and horizontal velocity curves compensate this small error. In order to obtain accurate results by the foregoing method, it is evident that the meter used must be of such construction as not to be affected by the vertical motion.

METHOD OF PLOTTING AND REDUCING OBSERVATIONS.

The total number of velocity observations taken during the past season at Thompsonville was 1,434; of these, 1,266 were taken in the vertical velocity planes. In addition to the use of these observations for determining the mean velocity and discharge of the river at different stages, they have been plotted and grouped in various ways to ascertain the character and form of the curves.

The observations were first all plotted upon section-paper, showing the velocities at each foot in depth in each vertical plane. At the bottom, a velocity was assumed and marked upon the section, corresponding as nearly as possible with the general direction and curve of the points above.

With the float observations this point was sometimes a little doubtful, and the person placing it might be somewhat influenced by preconceived opinions as to its exact position; but with the meter observations, the lowest velocity measured was so near the bottom that there could be but very little variation in following the general line of the points above and locating the bottom velocity upon the section.

Lines were then drawn through the points at the ends of the ordinates representing the velocity at the different depths in each section, with no attempt to modify the form. All of the sections were then divided into tenths of the total depth for the purpose of comparison. Two methods of comparing and taking the means of these vertical-velocity curves have been employed; one by computation only, to determine more exactly the form of the mean curves, and the other by graphic methods of grouping, to endeavor to ascertain if the number of observations would be sufficient to show a different form of curve in different sections across the river.

For the first method, the ordinates at the surface and at each tenth in depth to the bottom were taken from the plots of the velocities before described and the arithmetical means computed for each depth.

The mean of all the meter sections having a mean velocity below 1.86 feet per second, which was assumed as a division between the high and low velocities, was first computed. The result is plotted in Figure 1 of the sheet of diagrams of vertical curves of current velocities herewith submitted.

The corresponding mean curve of all the float sections having a mean velocity of less than 1.86 feet per second was next computed. The result is shown in Figure 2 of the diagram.

The mean of all the above sections was then taken to ascertain the mean curve of low velocities with both meters and floats. The result is plotted in Figure 3 of the diagrams.

The means of all the meter and float sections having an average velocity above 1.86 feet per second were then computed, separately and combined, as described for the low velocities, in order to ascertain the mean curve for high velocities. These results are shown in Figures 4, 5, and 6 of the diagrams.

The mean of all the meter curves, the mean of all the float curves, and the grand mean of all, were then computed. These results are shown in Figures 7, 8, and 9 of the diagrams.

The numerical means from which these figures, 1 to 9, are plotted are given in a tabular form farther on, following the tables of vertical velocities from which they are deduced.

In order to further compare these results, and observe more distinctly what differences there might be in the general form of the curves, they were all reduced to a mean velocity of unity by graphically dividing all the ordinates in each curve by its mean velocity and plotting the results in Figure 10 to 18 immediately under the corresponding original curve.

In the second method of grouping and arranging the vertical-velocity curves, the meter and float observations were taken separately; mainly on account of the meters running so much nearer the bottom, at the sides of the river, than was the case with the floats, and therefore being more useful in determining the different form of the curve in the different portions of the river-bed.

The sections across the river at F, G, and B were divided into seven divisions, and at C, into five divisions. These divisions were nearly equal, but were taken up so as to include characteristic portions of the river-bed; some of the divisions having sloping bottoms near the banks, and others being nearly flat near the middle.

The vertical-velocity curves were grouped in each of these divisions, and, for the purpose of comparing those of different depths and velocities, they were reduced to the same effective depth by taking tenths of the total depth, and to the same velocity by taking the mean velocity of the section equal to unity.

The method of determining the mean velocity in each curve was different from the one before used, of taking the mean of the velocities at each tenth of the depth. In this second method the mean velocities were obtained by taking the area of the figure formed by the velocity ordinates with a planimeter adjusted to the scale of the section-paper, and dividing this area by the depth. This gives the true mean, however irregular the figures may be. Two independent measurements of each figure were made with the planimeter, and they rarely differed more than $\frac{1}{2000}$ of the area.

The curves grouped in divisions were then plotted all to the same depth and mean velocity by setting a pair of proportional dividers with the opening at one end at unity, and the other at the actual mean velocity of each section, and transferring the distances out mechanically to the new section in the division group.

The result of this grouping was that with the number of curves taken no material difference was observed between the curves in the middle and at the sides of the river; at least none that was not more than counterbalanced by the local irregularities in each section.

In each of the divisions a curve was drawn averaging the lines plotted, and the mean of these curves in the several divisions across the river was taken and plotted. These means are shown in Figures 19 to 23, for the meter observations, and in Figures 25 and 26 for the floats. The means of all the meter and float observations were then found by combining these last sets of curves, and plotted in Figures 24 and 27. In these

last groupings the curves are slightly different from those obtained by taking the means arithmetically, for two reasons:

First, in the means obtained by computation, the sections containing uncertain or suspected bottom velocities were omitted, and the means taken of the others; while in the means obtained by the graphic methods all the vertical sections are included.

Second, in the first method equal weights are given to each section in taking the means; while in the second method equal weights are given to divisions, some of which contain a greater number of sections than the others.

Neither of the foregoing methods is advanced as a mathematical deduction of the law of the curves. They are given only to show the general form. For exact determinations of the law of the curves neither of these methods is strictly correct. Of the two, preference should be given to the numerical means.

During the season when the herein-described current experiments were made at Thompsonville, the winds were generally very light, and the greater part of the observations were but slightly affected by the effect of the wind upon the surface of the water. The curves were grouped in various ways to determine the amount of wind effect, but the results have not been very satisfactory. It appears from some of the observations that other causes than the effect of the wind raised and lowered the thread of greatest velocity, which the number of observations taken was not sufficient to eliminate. The best result that could be obtained was that the axis of the vertical curve was raised or lowered about $\frac{1}{100}$ of the depth for each mile per hour the wind was blowing down or up stream.

TABLES OF VERTICAL-VELOCITY CURVES.

The results of the observations taken in vertical planes at Thompsonville have been arranged in a tabular form for convenience of reference.

The surface and bottom velocities assumed for the purpose of computing the means and taking the velocities at tenths of the depths in the comparisons of the several curves are marked thus *.

Where the observations were taken with current-meters, the nearest that the meter could be run to the surface has been taken for the surface velocity. At the bottom, which the meter could not reach within about four-tenths of a foot, the velocity has been assumed, and the figures in the tables are marked thus *.

The method adopted for obtaining the nearest approximation to the mean velocity of the river for each particular curve has been to group a series across the river, having nearly the same height of water, and taken as nearly as possible at the same time, and take the mean height of these to give the area for computing the mean velocity of the whole section; then to find how much this mean would be increased or diminished by slight changes in the rise and fall of the surface, and to vary its value for each vertical curve according as the surface at the time it was taken was higher or lower than the assumed mean. This gives a close approximation to what would be the actual mean velocity at the time the particular observations were taken. The numbers of the several planes in the following table are given in the order in which they were originally plotted, commencing from the east bank, which does not in all cases correspond with the dates or order in which they were taken.

FLOAT OBSERVATIONS AT POSITION F.

No. 1, *taken May* 12, 1874.

Distance out from east base, 130 feet.

Height of surface of water above Hartford zero .....feet.. 45.213
Mean in vertical plane by observed velocities.....feet per second.. 2.39
Mean velocity of river .....feet per second.. 2.87

Direction and force of wind, southeast, 1 to 2. †

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	2.81*	2	2.90	5	2.80	8	2.27*
0.35	2.82	3	2.90	6	2.80		
1	2.92	4	2.88	7	2.65		

† Each degree of the force of the wind is about 2½ miles per hour.

No. 2, taken May 12.

Distance out from east base, 229 feet.

it of surface of water above Hartford zero.....feet.. 45.213
in vertical plane by observed velocities.....feet per second.. 2.81
velocity of river .....feet per second.. 2.87

ection and force of wind, southeast, 1 to 2.

Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
3.20*	3	3.10	7	2.82	11	2.78
3.20	4	3.15	8	2.98	12	2.77
3.20	5	3.08	9	2.92	16.5	1.75*
3.15	6	3.13	10	2.96		

No. 3, taken May 13.

Distance out from east base, 327 feet.

it of surface of water above Hartford zero.....feet.. 44.508
in vertical plane by observed velocities.....feet per second.. 2.57
velocity of river.....feet per second.. 2.55

ection and force of wind, southeast, 1.

Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
3.08*	5	2.80	11	2.90	17	2.43
3.08	6	2.94	12	2.69	18	2.25
3.01	7	2.86	13	2.55	21	1.82*
3.06	8	2.72	14	2.58		
2.88	9	2.84	15	2.44		
2.85	10	2.78	16	2.34		

No. 4, taken May 13.

Distance out from east base, 447 feet.

it of surface of water above Hartford zero.....feet.. 44.508
in vertical plane by observed velocities.....feet per second.. 2.70
velocity of river.....feet per second.. 2.53

ection and force of wind, south, 1.

Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
3.10*	5	2.95	11	2.82	17	2.34
3.10	6	2.99	12	2.65	18	2.44
3.08	7	3.04	13	2.69	19	2.30
3.03	8	3.04	14	2.64	20	2.17
3.15	9	2.96	15	2.65	22	1.82*
2.88	10	2.96	16	2.69		

No. 5, *taken May* 15.

Distance out from east base, 544 feet.

Height of surface of water above Hartford zero.....feet..
Mean in vertical plane by observed velocities.....feet per second..
Mean velocity of river.....feet per second..

Direction and force of wind, southeast, 0 to 2.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observ ity pe
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*F*
0	3.10*	5	3.13	11	2.86	17	2
0.35	3.10	6	2.92	12	2.92	18	2
1	3.03	7	3.10	13	2.63	19	2
2	3.03	8	2.80	14	2.86	20	1
3	2.99	0	3.06	15	2.65		
4	2.97	10	2.88	16	2.65		

No. 6, *taken May* 20.

Distance out from east base, 636 feet.

Height of surface of water above Hartford zero.....feet..
Mean in vertical plane by observed velocities.....feet per second..
Mean velocity of river.....feet per second..

Direction and force of wind, southeast, 1.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observ ity pe
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*F*
0	3.38*	5	3.39	11	2.67	17	2
0.35	3.39	6	3.45	12	2.99	18	2
1	3.28	7	3.23	13	2.63	19.7	1
2	3.48	8	3.26	14	2.82		
3	3.31	9	2.86	15	2.84		
4	3.54	10	2.99	16	2.69		

No. 7, *taken May* 22.

Distance out from east base, 735 feet.

Height of surface of water above Hartford zero.....feet..
Mean in vertical plane by observed velocities.....feet per second..
Mean velocity of river.....feet per second..

Direction and force of wind, northwest, 2 to 4.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observ ity pe
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*F*
0	3.64	5	3.61	11	3.54	17	2
0.35	3.64	6	3.48	12	3.48	17	2
1	3.75	7	3.28	13	3.08	19	2
2	3.54	8	3.57	14	3.08	19.9	2
3	3.64	9	3.64	15	2.99		
4	3.81	10	3.57	16	2.57		

No. 8, taken May 26.

Distance out from east base, 841 feet.

Height of surface of water above Hartford zero ..... feet.. 45.217
Mean in vertical plane by observed velocities ..... feet per second.. 3.00
Mean velocity of river ..... feet per second.. 2.89

Direction and force of wind, southwest, 1.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	3.32*	4	3.17	9	2.84	14	2.88
0.35	3.33	5	3.28	10	3.18	15	2.47
1	3.36	6	3.26	11	3.06	16	2.47
2	3.23	7	3.36	12	2.97	17	2.06
3	2.99	8	3.36	13	3.01	17.8	1.78*

No. 9, taken May 26.

Distance out from east base, 945 feet.

Height of surface of water above Hartford zero ..... feet.. 45.217
Mean in vertical plane by observed velocities ..... feet per second.. 3.01
Mean velocity of river ..... feet per second.. 2.89

Direction and force of wind, northwest, 2.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	3.17*	4	3.23	9	2.88	14	2.38
0.35	3.17	5	3.15	10	2.75	15	2.07*
1	3.31	6	3.31	11	2.84		
2	3.34	7	3.15	12	2.88		
3	3.26	8	3.23	13	2.88		

No. 10, taken May 27.

Distance out from east base, 1,037 feet.

Height of surface of water above Hartford zero ..... feet.. 44.884
Mean in vertical plane by observed velocities ..... feet per second.. 2.78
Mean velocity of river ..... feet per second.. 2.70

Direction and force of wind, northwest, 1.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	3.32*	3	3.06	7	2.90	11	2.15
0.35	3.33	4	2.96	8	2.76	12.3	1.66*
1	3.15	5	2.95	9	2.74		
2	3.13	6	3.01	10	2.50		

No. 11, *taken May 27.*

Distance out from east base, 1,142 feet.

Height of surface of water above Hartford zero .....feet..
Mean in vertical plane by observed velocities.....feet per second..
Mean velocity of river.....feet per second..

Direction and force of wind, northwest, 1.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observ ity per
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*F*
0	2.82*	2	2.56	5	2.26	8	1.
0.35	2.82	3	2.57	6	2.19	10.8	1.
1	2.77	4	2.57	7	2.17		

FLOAT OBSERVATIONS AT POSITION G.

No. 12, *taken June* 16.

Distance out from east base, 549 feet.

Height of surface of water above Hartford zero .....feet..
Mean in vertical plane by observed velocities.....feet per second..
Mean velocity of river.....feet per second..

Direction and force of wind, south-southeast, 2.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observ ity per
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*F*
0	1.42*	4	1.43	9	1.46	14	1.
0.35	1.43	5	1.44	10	1.28	15	1.
1	1.43	6	1.41	11	1.33	16	0.
2	1.39	7	1.37	12	1.25	17	0.
3	1.31	8	1.41	13	1.28		

No. 13, *taken June* 15.

Distance out from east base, 646 feet.

Height of surface of water above Hartford zero .....feet..
Mean in vertical plane by observed velocities.....feet per second..
Mean velocity of river.....feet per second..

Direction and force of wind, calm.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observ ity per
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*F*
0	1.76*	4	1.72	9	1.64	14	1.
0.35	1.76	5	1.69	10	1.47	15	1.
1	1.72	6	1.69	11	1.40	16	0.
2	1.65	7	1.66	12	1.46		
3	1.73	8	1.64	13	1.41		

No. 14, *taken June* 15.

Distance out from east base, 744 feet.

Height of surface of water above Hartford zero.....feet.. 41.423
Mean in vertical plane by observed velocities.....feet per second.. 1.51
Mean velocity of river.....feet per second.. 1.17

Direction and force of wind, calm.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	1.62*	4	1.65	9	1.52	14	1.10
0.35	1.63	5	1.73	10	1.50	15.5	0.78*
1	1.77	6	1.79	11	1.39		
2	1.71	7	1.58	12	1.39		
3	1.70	8	1.62	13	1.26		

No. 15, *taken June* 12.

Distance out from east base, 841 feet.

Height of surface of water above Hartford zero.....feet.. 41.631
Mean in vertical plane by observed velocities.....feet per second.. 1.53
Mean velocity of river.....feet per second.. 1.30

Direction and force of wind, northeast, 1.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	1.64*	4	1.71	9	1.53	14	0.78
0.35	1.65	5	1.74	10	1.61	15	0.30*
1	1.67	6	1.64	11	1.44		
2	1.86	7	1.77	12	1.52		
3	1.74	8	1.65	13	1.25		

No. 16, *taken June* 12.

Distance out from east base, 953 feet.

Height of surface of water above Hartford zero.....feet.. 41.631
Mean in vertical plane by observed velocities.....feet per second.. 1.26
Mean velocity of river.....feet per second.. 1.30

Direction and force of wind, southwest, 1.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	1.30*	3	1.44	7	1.32	12	0.73*
0.35	1.29	4	1.52	8	1.33		
1	1.32	5	1.43	9	1.10		
2	1.45	6	1.33	10	1.06		

No. 17, *taken June* 9.

Distance out from east base, 1,040 feet.

Height of surface of water above Hartford zero .....feet.. 43.0
Mean in vertical plane by observed velocities .....feet per second.. 1.3
Mean velocity of river.....feet per second.. 1.8

Direction and force of wind, southwest, 2.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	1.54*	2	1.53	5	1.57	8	1.21
0.35	1.54	3	1.56	6	1.41	9	0.87
1	1.52	4	1.54	7	1.33	10.3	0.42*

No. 18, *taken June* 9.

Distance out from east base, 1,149 feet.

Height of surface of water above Hartford zero.....feet.. 43.0
Mean in vertical plane by observed velocities.....feet per second.. 1.2
Mean velocity of river.....feet per second.. 1.8

Direction and force of wind, calm.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	1.42*	2	1.47	5	1.26	8	0.69*
0.35	1.42	3	1.39	6	1.10		
1	1.47	4	1.33	6.5	1.02		

No. 19, *taken June* 25.

Distance out from east base, 1,070 feet.

Height of surface of water above Hartford zero.....feet.. 41.6
Mean in vertical plane by observed velocities.....feet per second.. 0.9
Mean velocity of river .....feet per second.. 1.3

Direction and force of wind, west-northwest, 1.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	1.22*	2	1.16	5	0.96	8.5	0.31*
0.35	1.23	3	1.20	6	0.95		
1	1.21	4	1.06	7	0.80		

No. 20, taken June 25.

Distance out from east base, 1,168 feet.

Height of surface of water above Hartford zero.....feet.. 41.64
Mean in vertical plane by observed velocities .....feet per second.. 0.71
Mean velocity of river.....feet per second.. 1.38

Direction and force of wind, west-northwest, 1.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	0.86*	1	0.86	3	0.88	4.5	0.72
0.35	0.88	2	0.85	4	0.65	6	0.38*

METER-OBSERVATIONS AT POSITION F.

Current-meter, No. 1.

No. 1, taken May 12.

Distance out from east base, 130 feet.

Height of surface of water above Hartford zero.....feet.. 45.213
Mean in vertical plane by observed velocities.....feet per second.. 2.38
Mean velocity in vertical plane by integration.....feet per second.. 2.59
Mean velocity of river.....feet per second.. 2.87

Direction and force of wind, southeast, 1.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	2.88	3	2.76	6	2.49	8.8	0.41*
1	2.71	4	2.67	7	2.20		
2	2.69	5	2.53	8	1.19		

No. 2, taken May 12.

Distance out from east base, 229 feet.

Height of surface of water above Hartford zero.....feet.. 45.213
Mean in vertical plane by observed velocities.....feet per second.. 2.72
Mean velocity in vertical plane by integration.....feet per second.. 2.75
Mean velocity of river.....feet per second.. 2.87

Direction and force of wind, southeast, 1 and 2.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	3.12	5	2.97	10	2.58	15	1.91
1	3.06	6	2.95	11	2.61	15.8	1.43*
2	3.19	7	2.83	12	2.41		
3	3.21	8	2.87	13	2.47		
4	3.13	9	2.72	14	2.44		

No. 3, *taken May* 13.

Distance out from east base, 341 feet.

Height of surface of water above Hartford zero.....feet.
Mean in vertical plane by observed velocities.....feet per second.
Mean velocity in vertical plane by integration.....feet per second.
Mean velocity of river.....feet per second.

Direction and force of wind, south, 1.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Obse ity p
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	
0	2.31	6	2.86	12	2.48	18	
1	2.86	7	2.67	13	2.43	19	
2	2.94	8	2.77	14	2.50	20	
3	2.94	9	2.72	15	2.27	21	
4	2.86	10	2.45	16	2.33	21.8	
5	2.69	11	2.50	17	2.01		

No. 4, *taken May* 14.

Distance out from east base, 448 feet.

Height of surface of water above Hartford zero.....feet.
Mean in vertical plane by observed velocities.....feet per second.
Mean velocity in vertical plane by integration.....feet per second.
Mean velocity of river.....feet per second.

Direction of force of wind, northwest, 1.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Obse ity p
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	
0	2.66	6	2.80	12	2.41	18	
1	2.55	7	2.85	13	2.41	19	
2	2.91	8	2.67	14	2.49	20	
3	2.87	9	2.60	15	2.42	21.9	
4	2.80	10	2.59	16	2.54		
5	2.74	11	2.52	17	2.40		

No. 5, *taken May* 20.

Distance out from east base, 542 feet.

Height of surface of water above Hartford zero.....feet.
Mean in vertical plane by observed velocities.....feet per second.
Mean velocity in vertical plane by integration.....feet per second
Mean velocity of river.....feet per second

Direction and force of wind, southwest, 3.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Obse ity p
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	
0	3.09	6	3.10	12	2.85	18	
1	3.34	7	3.17	13	2.78	19	
2	3.20	8	2.85	14	2.88	20	
3	3.20	9	3.07	15	2.75	21.7	
4	3.33	10	3.06	16	2.90		
5	3.23	11	2.82	17	1.90		

No. 6, taken May 22.

Distance out from east base, 634 feet.

Height of surface of water above Hartford zero	feet..	45.484
Mean in vertical plane by observed velocities	feet per second..	2.94
Mean velocity in vertical plane by integration	feet per second..	2.97
Mean velocity of river	feet per second..	3.01

Direction and force of wind, northwest, 3.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	3.05	6	3.43	12	2.95	18	2.51
1	3.40	7	3.34	13	2.78	19	2.21
2	3.63	8	2.99	14	2.42	20	2.29
3	3.52	9	2.83	15	2.71	20.5	2.04*
4	3.44	10	3.33	16	2.34		
5	3.19	11	3.09	17	2.38		

No. 7, taken May 23.

Distance out from east base, 730 feet.

Height of surface of water above Hartford zero	feet..	45.829
Mean in vertical plane by observed velocities	feet per second..	2.91
Mean velocity in vertical plane by integration	feet per second..	3.28
Mean velocity of river	feet per second..	3.08

Direction and force of wind, calm.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	2.71	6	3.31	12	3.03	18	2.33
1	3.52	7	3.42	13	2.94	19	2.08
2	3.73	8	3.13	14	2.12	20	1.99
3	3.48	9	3.34	15	1.91	20.7	1.74*
4	3.50	10	3.46	16	2.76		
5	3.55	11	2.74	17	2.33		

No. 8, taken May 26.

Distance out from east base, 845 feet.

Height of surface of water above Hartford zero	feet..	45.217
Mean in vertical plane by observed velocity	feet per second..	2.96
Mean velocity in vertical plane by integration	feet per second..	2.99
Mean velocity of river	feet per second..	2.89

Direction and force of wind, northwest, 2.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	3.36	5	3.17	10	2.94	15	2.42
1	3.15	6	3.07	11	2.90	16	1.87
2	3.37	7	3.33	12	2.62	16.6	1.98
3	3.35	8	3.35	13	2.89	17.1	1.58
4	3.44	9	2.82	14	2.76		

No. 9, taken May 26.

Distance out from east base, 938 feet.

Height of surface of water above Hartford zero.....feet.. 45.2[illegible]
Mean in vertical plane by observed velocities.....feet per second.. 3.0[illegible]
Mean velocity in vertical plane by integration.....feet per second.. 3.0[illegible]
Mean velocity of river.....feet per second.. 2.8[illegible]

Direction and force of wind, northwest, 2.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	3.32	5	3.42	10	2.90	14.7	2.52
1	3.19	6	3.18	11	2.89	15.6	2.03*
2	3.33	7	3.15	12	2.80		
3	3.38	8	3.18	13	2.56		
4	3.31	9	3.33	14	2.60		

No. 10, taken May 27.

Distance out from east base, 1,038 feet.

Height of surface of water above Hartford zero.....feet.. 44.884
Mean in vertical plane by observed velocities.....feet per second.. 2.63
Mean velocity in vertical plane by integration.....feet per second.. 2.71
Mean velocity of river.....feet per second.. 2.70

Direction and force of wind, northwest, 1.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	2.65	4	2.98	8	2.53	11.4	1.92
1	2.94	5	2.98	9	2.52	12.2	1.34*
2	3.07	6	2.65	10	2.39		
3	3.10	7	2.75	11	2.24		

No. 11, taken May 27.

Distance out from east base, 1,132 feet.

Height of surface of water above Hartford zero.....feet.. 44.884
Mean in vertical plane by observed velocities.....feet per second.. 2.32
Mean velocity in vertical plane by integration.....feet per second.. 2.39
Mean velocity of river.....feet per second.. 2.70

Direction and force of wind, northwest, 1.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	2.54	3	2.57	6	2.09	9	2.00
1	2.60	4	2.60	7	2.21	9.6	1.76
2	2.60	5	2.31	8	2.07	10	1.48*

No. 12, taken May 27.

Distance out from east base, 1,200 feet.

Height of surface of water above Hartford zero	feet..	44.884
Mean in vertical plane by observed velocities	feet per second..	1.19
Mean velocity in vertical plane by integration	feet per second..	1.27
Mean velocity of river	feet per second..	2.70

Direction and force of wind, northwest, 1.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	1.08	2	1.36	3.4	1.06		
1	1.23	3	1.08	4.2	0.83*		

METER-OBSERVATIONS AT POSITION G.

Current-meter, No. 1.

No. 13, taken June 18.

Distance out from east base, 102 feet.

Height of surface of water above Hartford zero	feet..	42.083
Mean in vertical plane by observed velocities	feet per second..	0.79
Mean velocity in vertical plane by integration	feet per second..	0.84
Mean velocity of river	feet per second..	1.41

Direction and force of wind, northwest, 4 and 5.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	0.90	2	1.06	4	0.42	5.4	0.34*
1	0.81	3	0.93	5	0.52		

No. 14, taken June 18.

Distance out from east base, 195 feet.

Height of surface of water above Hartford zero	feet..	42.083
Mean in vertical plane by observed velocities	feet per second..	0.92
Mean velocity in vertical plane by integration	feet per second..	0.96
Mean velocity of river	feet per second..	1.41

Direction and force of wind, northwest, 4.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	1.29	4	1.24	8	0.99	12	0.55
1	1.25	5	1.13	9	0.97	13	0.54
2	1.33	6	1.20	10	1.05	13.9	0.38
3	1.19	7	0.85	11	0.89	14.3	0.25*

No. 15, *taken June* 18.

Distance out from east base, 309 feet.

Height of surface of water above Hartford zero .....feet.. 42.0
Mean in vertical plane by observed velocities .....feet per second.. 1.
Mean velocity in vertical plane by integration.....feet per second.. 1.
Mean velocity of river.....feet per second.. 1.

Direction and force of wind, northwest, 4.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	1.49	6	1.50	12	1.27	18	0.88
1	1.49	7	1.49	13	1.23	19	0.62
2	1.56	8	1.59	14	1.26	19.4	0.36*
3	1.59	9	1.30	15	1.24		
4	1.60	10	1.24	16	0.92		
5	1.57	11	1.32	17	0.94		

No. 16, *taken June* 16.

Distance out from east base, 309 feet.

Height of surface of water above Hartford zero.....feet.. 41.3
Mean in vertical plane by observed velocities .....feet per second.. 1.0
Mean velocity in vertical plane by integration .....feet per second.. 1.0
Mean velocity of river.....feet per second.. 1.1

Direction and force of wind, southeast, 4.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	0.98	6	1.22	12	1.15	18	0.46
1	0.96	7	1.22	13	1.22	18.4	0.63
2	1.21	8	1.21	14	0.95	18.8	0.29*
3	1.25	9	1.14	15	0.96		
4	1.13	10	1.08	16	1.02		
5	1.23	11	1.21	17	0.76		

No. 17, *taken June* 16.

Distance out from east base, 437 feet.

Height of surface of water above Hartford zero.....feet.. 41.3
Mean in vertical plane by observed velocities.....feet per second.. 1.3
Mean velocity in vertical plane by integration .....feet per second.. 1.2
Mean velocity of river .....feet per second.. 1.1

Direction and force of wind, southeast, 4.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	1.60	5	1.54	10	1.46	15	1.27
1	1.43	6	1.57	11	1.43	16	0.89
2	1.42	7	1.53	12	1.28	17	1.11
3	1.51	8	1.40	13	1.27	17.8	0.72
4	1.61	9	1.52	14	1.31	18.2	0.46*

No. 18, *taken June* 15.

Distance out from east base, 546 feet.

Height of surface of water above Hartford zero.....feet.. 41.423
Mean in vertical plane by observed velocities.....feet per second.. 1.41
Mean velocity in vertical plane by integration .....feet per second.. 1.45
Mean velocity of river .....feet per second.. 1.17

Direction and force of wind, calm.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	1.58	5	1.59	10	1.42	15	1.23
1	1.58	6	1.59	11	1.40	16	1.09
2	1.61	7	1.54	12	1.23	16.8	0.92
3	1.49	8	1.49	13	1.23	17.2	0.73*
4	1.64	9	1.49	14	1.15		

No. 19, *taken June* 15.

Distance out from east base, 652 feet.

Height of surface of water above Hartford zero.....feet.. 41.423
Mean in vertical plane by observed velocities.....feet per second.. 1.44
Mean velocity in vertical plane by integration.....feet per second.. 1.42
Mean velocity of river .....feet per second.. 1.17

Direction and force of wind, calm.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	1.62	5	1.74	10	1.49	15	1.20
1	1.45	6	1.57	11	1.39	15.8	0.89
2	1.60	7	1.45	12	1.43	16.2	0.64*
3	1.59	8	1.51	13	1.16		
4	1.63	9	1.51	14	1.22		

No. 20, *taken June* 10.

Distance out from east base, 756 feet.

ight of surface of water above Hartford zero.....feet.. 42.747
an in vertical plane of observed velocities.....feet per second.. 2.01
an velocity in vertical plane by integration.....feet per second.. 1.97
an velocity of river.....feet per second.. 1.70

Direction and force of wind, calm.

epth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	2.17	5	2.03	10	1.95	15	1.47
1	2.11	6	2.07	11	1.98	16	1.29
2	2.06	7	2.15	12	1.82	16.4	1.14*
3	2.19	8	2.18	13	1.91		
4	2.20	9	2.16	14	1.89		

No. 21, taken June 10.

Distance out from east base, 858 feet.

Height of surface of water above Hartford zero.....feet.. 42.7[illegible]
Mean in vertical plane by observed velocities.....feet per second.. 1.9[illegible]
Mean velocity in vertical plane by integration.....feet per second.. 1.9[illegible]
Mean velocity of river.....feet per second.. 1.7[illegible]

Direction and force of wind, calm.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	2.14	5	2.16	10	1.86	14.7	1.33
1	2.07	6	2.08	11	1.81	15.1	1.09*
2	2.07	7	2.05	12	1.73		
3	2.11	8	1.95	13	1.65		
4	2.15	9	1.96	14	1.69		

No. 22, taken June 10.

Distance out from east base, 949 feet.

Height of surface of water above Hartford zero.....feet.. 42.747
Mean in vertical plane by observed velocities.....feet per second.. 1.64
Mean velocity in vertical plane by integration.....feet per second.. 1.66
Mean velocity of river.....feet per second.. 1.70

Direction and force of wind, calm.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	1.83	4	1.86	8	1.68	12	1.30
1	1.90	5	1.79	9	1.41	12.3	1.06
2	1.88	6	1.66	10	1.42	12.7	0.72*
3	1.80	7	1.62	11	1.39		

No. 23, taken June 10.

Distance out from east base, 1,040 feet.

Height of surface of water above Hartford zero.....feet.. 42.747
Mean in vertical plane by observed velocities.....feet per second.. 1.42
Mean velocity in vertical plane by integration.....feet per second.. 1.45
Mean velocity of river.....feet per second.. 1.70

Direction and force of wind, north, 1.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	1.61	3	1.53	6	1.46	9	1.07
1	1.58	4	1.58	7	1.37	9.9	0.66
2	1.60	5	1.39	8	1.35	10.3	0.53*

No. 24, taken June 9.

Distance out from east base, 1,176 feet.

Height of surface of water above Hartford zero	feet..	43.097
Mean in vertical plane by observed velocities	feet per second..	0.92
Mean velocity in vertical plane by integration		not taken.
Mean velocity of river	feet per second..	1.80

Direction and force of wind, south-southwest, 1.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	1.00	3	1.12	6	0.75		
1	1.07	4	0.96	6.5	0.35		
2	1.14	5	0.87	6.9	0.10*		

METER-OBSERVATIONS AT POSITION B.

Current-meter, No. 1.

No. 25, taken May 28.

Distance out from east base, 83 feet.

Height of surface of water above Hartford zero	feet..	44.30
Mean in vertical plane by observed velocities	feet per second..	2.66
Mean velocity in vertical plane by integration	feet per second..	2.83
Mean velocity of river	feet per second..	3.50

Direction and force of wind, northwest, 1.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	2.86	3	3.05	6	2.28	8	1.33*
1	2.93	4	2.89	7	2.01		
2	3.06	5	2.78	7.5	1.57		

No. 26, taken May 28.

Distance out from east base, 197 feet.

Height of surface of water above Hartford zero	feet..	44.30
Mean in vertical plane by observed velocities	feet per second..	3.47
Mean velocity in vertical plane by integration	feet per second..	3.35
Mean velocity of river	feet per second..	3.50

Direction and force of wind, northwest, 1.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	3.68	3	3.80	6	3.26	8	1.83*
1	4.00	4	3.91	7	2.94		
2	3.92	5	3.16	7.6	2.43		

No. 27, taken May 28.

Distance out from east base, 312 feet.

Height of surface of water above Hartford zero ....feet.. 44
Mean in vertical plane by observed velocities .....feet per second.. 3
Mean velocity in vertical plane by integration .....feet per second.. 3
Mean velocity of river .....feet per second.. 3

Direction and force of wind, northwest, 1.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	4.07	3	3.84	6	3.13	8	2.09*
1	4.09	4	3.65	7	2.64		
2	4.20	5	3.51	7.6	2.42		

No. 28, taken May 28.

Distance out from east base, 425 feet.

Height of surface of water above Hartford zero .....feet.. 4
Mean in vertical plane by observed velocities .....feet per second..
Mean velocity in vertical plane by integration .....feet per second..
Mean velocity of river .....feet per second..

Direction and force of wind, southwest, 1.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	3.96	3	4.25	6	3.12	7.6	2.18*
1	4.41	4	3.78	7	2.48		
2	4.13	5	3.62	7.2	2.66		

No. 29, taken May 28.

Distance out from east base, 530 feet.

Height of surface of water above Hartford zero .....feet.. 4
Mean in vertical plane by observed velocities .....feet per second..
Mean velocity in vertical plane by integration .....feet per second..
Mean velocity of river .....feet per second..

Direction and force of wind, southwest, 2.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	4.05	3	4.04	6	3.66	9	2.77
1	3.95	4	4.02	7	3.42	9.9	2.39
2	4.18	5	4.03	8	3.47	10.3	2.00*

No. 30, taken May 28.

Distance out from east base, 610 feet.

Height of surface of water above Hartford zero	feet..	44.30
Mean in vertical plane by observed velocities	feet per second..	3.63
Mean velocity in vertical plane by integration	feet per second..	3.72
Mean velocity of river	feet per second..	3.50

Direction and force of wind, southwest, 2.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	4.30	5	3.95	10	3.71	15	2.25
1	3.87	6	3.86	11	3.51	15.5	1.89*
2	4.43	7	4.04	12	2.56		
3	4.30	8	4.13	13	2.86		
4	4.28	9	3.96	14	2.39		

No. 31, taken May 28.

Distance out from east base, 710 feet.

Height of surface of water above Hartford zero	feet..	44.30
Mean in vertical plane by observed velocities	feet per second..	3.94
Mean velocity in vertical plane by integration	feet per second..	3.95
Mean velocity of river	feet per second..	3.50

Direction and force of wind, northwest, 3.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	4.29	4	4.42	8	3.92	11.5	2.59
1	4.88	5	4.30	9	3.59	12	1.63*
2	4.31	6	3.79	10	3.48		
3	4.63	7	4.11	11	2.65		

No. 32, taken May 29.

Distance out from east base, 836 feet.

Height of surface of water above Hartford zero	feet..	43.666
Mean in vertical plane by observed velocities	feet per second..	3.97
Mean velocity in vertical plane by integration	feet per second..	4.41
Mean velocity of river	feet per second..	3.21

Direction and force of wind, northwest, 1.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	3.75	3	4.36	6	3.48		
1	4.05	4	4.32	6.9	3.18		
2	4.63	5	3.96	7.5	2.86*		

No. 33, taken May 29.

Distance out from east base, 910 feet.

Height of surface of water above Hartford zero.....feet.. 43.666
Mean in vertical plane by observed velocities.....feet per second.. 3.53
Mean velocity in vertical plane by integration.....feet per second.. 3.78
Mean velocity of river.....feet per second.. 3.21

Direction and force of wind, calm.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	3.99	3	4.25	6	3.83		
1	3.81	4	3.92	7	3.08		
2	4.27	5	3.83	7.6	2.81*		

No. 34, taken May 29.

Distance out from east base, 1,020 feet.

Height of surface of water above Hartford zero.....feet.. 43.666
Mean in vertical plane by observed velocities.....feet per second.. 3.51
Mean velocity in vertical plane by integration.....feet per second.. 3.50
Mean velocity of river.....feet per second.. 3.21

Direction and force of wind, calm.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	3.88	3	3.79	6	3.11		
1	3.97	4	3.88	6.7	2.58		
2	3.70	5	3.13	7.1	2.22*		

No. 35, taken May 29.

Distance out from east base, 1,140 feet.

Height of surface of water above Hartford zero.....feet.. 43.666
Mean in vertical plane by observed velocities.....feet per second.. 3.27
Mean velocity in vertical plane by integration.....feet per second.. 3.51
Mean velocity of river.....feet per second.. 3.21

Direction and force of wind, calm.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	3.39	3	3.39	6	2.96		
1	3.35	4	3.45	6.8	2.58		
2	3.70	5	3.55	7.2	2.29*		

No. 36, taken May 29.

Distance out from east base, 1,240 feet.

Height of surface of water above Hartford zero	feet..	43.666
Mean in vertical plane by observed velocities	feet per second..	2.92
Mean velocity in vertical plane by integration	feet per second..	3.12
Mean velocity of river	feet per second..	3.21

Direction and force of wind, southwest, 1.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	3.10	3	3.42	6	2.51	8	1.20*
1	3.46	4	2.92	7	1.96		
2	3.45	5	3.17	7.5	1.91		

No. 37, taken June 1.

Distance out from east base, 1,300 feet.

Height of surface of water above Hartford zero	feet..	42.277
Mean in vertical plane by observedvelocities	feet per second..	2.56
Mean velocity in vertical plane by integration	feet per second..	2.53
Mean velocity of river	feet per second..	2.56

Direction and force of wind, calm.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	2.79	3	2.97	6	2.55	8.9	1.46
1	2.90	4	2.74	7	2.37	9.3	0.73*
2	2.95	5	2.75	8	2,13		

METER-OBSERVATIONS AT POSITION C.

Current-meter No. 1.

No. 38, taken June 2.

Distance out from east base, 51 feet.

Height of surface of water above Hartford zero	feet..	42.387
Mean in vertical plane by observed velocities	feet per second..	0.49
Mean velocity in vertical plane by integration	feet per second..	0.46
Mean velocity of river	feet per second..	1.87

Direction and force of wind, northwest, 1.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	0.51	2	0.75	4	0.59	5.9	0.0
1	0.51	3	0.62	5	0.32	6.2	0.0*

No. 39, taken June 2.

Distance out from east base, 875 feet.

Height of surface of water above Hartford zero.....feet.. 42.3
Mean in vertical plane by observed velocities.....feet per second.. 0.5
Mean velocity in vertical plane by integration .....feet per second.. 0.9
Mean velocity of river.....feet per second.. 1.5

Direction and force of wind, northwest, 1.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	1.27	4	1.12	8	1.03	12	0.49
1	1.01	5	1.02	9	0.91	12.4	0.28
2	1.01	6	1.05	10	0.87	12.8	0.04*
3	1.07	7	0.96	11	0.64		

No. 40, taken June 2.

Distance out from east base, 215 feet.

Height of surface of water above Hartford zero.....feet.. 42.38
Mean in vertical plane by observed velocities.....feet per second.. 1.91
Mean velocity in vertical plane by integration .....feet per second.. 1.83
Mean velocity of river.....feet per second.. 1.87

Direction and force of wind, calm.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	2.27	6	2.16	12	1.96	18	1.48
1	2.16	7	2.04	13	1.92	18.9	1.02
2	2.19	8	2.07	14	1.91	19.3	0.65*
3	2.20	9	1.90	15	1.62		
4	2.12	10	2.02	16	1.64		
5	2.11	11	1.79	17	1.55		

No. 41, taken June 2.

Distance out from east base, 290 feet.

Height of surface of water above Hartford zero.....feet.. 42.38
Mean in vertical plane by observed velocities.....feet per second.. 2.51
Mean velocity in vertical plane by integration .....feet per second.. 2.46
Mean velocity of river.....feet per second.. 1.87

Direction and force of wind, calm.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	2.80	6	2.79	12	2.76	18	2.12
1	3.01	7	2.70	13	2.59	19	2.09
2	2.90	8	2.87	14	2.44	20	1.72
3	2.89	9	2.62	15	2.50	21	1.58
4	2.87	10	2.48	16	2.45	21.9	1.65
5	2.89	11	2.80	17	2.23	22.3	1.30*

No. 42, taken June 2.

Distance out from east base, 410 feet.

Height of surface of water above Hartford zero	feet..	42.387
Mean in vertical plane by observed velocities	feet per second..	2.71
Mean velocity in vertical plane by integration	feet per second..	2.70
Mean velocity of river	feet per second..	1.87

Direction and force of wind, calm.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	3.03	6	3.03	12	2.84	18	2.23
1	2.59	7	2.89	13	2.99	19	2.07
2	2.74	8	2.81	14	2.83	20	1.71
3	3.03	9	3.03	15	2.78	20.4	1.71
4	3.07	10	2.97	16	2.75	20.8	1.43*
5	2.84	11	2.73	17	2.36		

No. 43, taken June 2.

Distance out from east base, 454 feet.

Height of surface of water above Hartford zero	feet..	42.387
Mean in vertical plane by observed velocities	feet per second..	2.58
Mean velocity in vertical plane by integration	feet per second..	2.57
Mean velocity of river	feet per second..	1.87

Direction and force of wind, calm.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	2.45	6	2.71	12	2.60	18	1.82
1	2.58	7	2.86	13	2.62	19	1.78
2	2.93	8	2.72	14	2.32	19.3	1.83
3	2.92	9	2.80	15	2.32	19.7	1.56*
4	2.93	10	2.70	16	2.63		
5	2.84	11	2.70	17	2.42		

No. 44, taken June 3.

Distance out from east base, 515 feet.

Height of surface of water above Hartford zero	feet..	42.290
Mean in vertical plane by observed velocities	feet per second..	2.17
Mean velocity in vertical plane by integration	feet per second..	2.13
Mean velocity of river	feet per second..	1.81

Direction and force of wind, southwest, 3.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	2.54	6	2.42	12	2.15	18	1.72
1	2.56	7	2.40	13	1.92	19	1.36
2	2.71	8	2.24	14	1.96	19.3	1.29
3	2.49	9	2.29	15	2.04	19.7	1.07*
4	2.45	10	2.30	16	1.95		
5	2.35	11	2.08	17	1.90		

No. 45, taken June 2.

Distance out from east base, 600 feet.

Height of surface of water above Hartford zero.....feet.. 42.38
Mean in vertical plane by observed velocities.....feet per second.. 1.9
Mean velocity in vertical plane by integration.....feet per second.. 1.8
Mean velocity of river.....feet per second.. 1.8

Direction and force of wind, calm.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	2.01	5	2.11	10	1.91	15	1.65
1	1.71	6	2.09	11	2.05	16	1.52
2	1.99	7	2.05	12	1.95	17	1.28
3	2.11	8	2.01	13	2.00	17.4	1.10*
4	2.07	9	2.03	14	1.83		

No. 46, taken June 3.

Distance out from east base, 720 feet.

Height of surface of water above Hartford zero.....feet.. 42.2
Mean in vertical plane by observed velocities.....feet per second.. 1.4
Mean velocity in vertical plane by observation.....feet per second.. 1.4
Mean velocity of river.....feet per second.. 1.8

Direction and force of wind, southeast, 1.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	1.66	5	1.51	10	1.54	15	0.81
1	1.49	6	1.61	11	1.30	15.2	0.70
2	1.82	7	1.59	12	1.22	15.6	0.56*
3	1.68	8	1.53	13	1.08		
4	1.64	9	1.55	14	1.27		

No. 47, taken June 3.

Distance out from east base, 832 feet.

Height of surface of water above Hartford zero.....feet.. 42.
Mean in vertical plane by observed velocities.....feet per second.. 1.
Mean velocity in vertical plane by integration.....feet per second.. 1.
Mean velocity of river.....feet per second.. 1.

Direction and force of wind, southeast, 1.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	1.54	4	1.53	8	1.56	12	0.81
1	1.55	5		9	1.45	12.7	0.87
2	1.66	6	1.60	10	1.32	13.1	0.61
3	1.64	7	1.51	11	0.93		

No. 48, *taken June* 3.

Distance out from east base, 950 feet.

ht of surface of water above Hartford zero	feet..	42.29
ı in vertical plane by observed velocities	feet per second..	0.90
ı velocity in vertical plane by integration	feet per second..	0.93
ı velocity of river	feet per second..	1.81

rection and force of wind, southeast, 2.

th.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
t.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
)	1.03	3	0.96	6	0.80	8.3	0.50*
l	1.06	4	0.96	7	0.73		
!	0.97	5	1.01	7.9	0.60		

No. 49, *taken June* 3.

Distance out from east base, 996 feet.

ght of surface of water above Hartford zero	feet..	42.29
n in vertical plane by observed velocities	feet per second..	0.73
n velocity in vertical plane by integration	feet per second..	0.75
n velocity of river	feet per second..	1.81

rection and force of wind, south, 2.

h.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
	0.85	2	0.94	4	0.54	5.2	0.40*
	0.83	3	0.72	4.8	0.50		

No. 50, *taken June* 6.

Distance out from east base, 93 feet.

ht of surface of water above Hartford zero	feet..	42.07
ı in vertical plane by observed velocities	feet per second..	0.47
ı velocity in vertical plane by observation	feet per second..	0.45
ı velocity of river	feet per second..	1.75

rection and force of wind, calm.

h.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
	0.55	4	0.56	8	0.41	11.5	0
	0.56	5	0.47	9	0.34	11.9	0*
	0.63	6	0.66	10	0		
	0.71	7	0.65	11	0		

No. 51, *taken June* 6.

Distance out from east base, 310 feet.

Height of surface of water above Hartford zero ..... feet.. 42.
Mean in vertical plane by observed velocities ..... feet per second.. 2.
Mean velocity in vertical plane by integration ..... feet per second.. 2.
Mean velocity of river ..... feet per second.. 1.

Direction and force of wind, calm.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	2.42	6	2.54	12	2.23	18	1.98
1	2.19	7	2.58	13	2.18	19	1.75
2	2.34	8	2.46	14	2.43	20	1.84
3	2.52	9	2.46	15	2.32	21	1.49
4	2.48	10	2.47	16	2.02	21.1	1.45
5	2.46	11	2.22	17	1.94	21.5	1.24*

No. 52, *taken June* 6.

Distance out from east base, 507 feet.

Height of surface of water above Hartford zero ..... feet.. 42.0
Mean in vertical plane by observed velocities ..... feet per second.. 1.8
Mean velocity in vertical plane by integration ..... feet per second.. 1.9
Mean velocity of river ..... feet per second.. 1.7

Direction and force of wind, calm.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	2.11	6	2.04	12	1.90	18	1.48
1	1.86	7	1.91	13	1.74	19	1.38
2	2.16	8	2.07	14	1.84	19.8	0.89
3	2.15	9	2.03	15	1.91	20.2	0.55*
4	1.98	10	1.77	16	1.64		
5	2.08	11	1.95	17	1.67		

No. 53, *taken June* 6.

Distance out from east base, 707 feet.

Height of surface of water above Hartford zero ..... feet.. 42.
Mean in vertical plane by observed velocities ..... feet per second.. 1.
Mean velocity in vertical plane by integration ..... feet per second.. 0.
Mean velocity of river ..... feet per second.. 1.

Direction and force of wind, southwest, 1.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	1.30	5	1.12	10	0.91	15	0.36
1	1.30	6	1.12	11	0.94	15.4	0.29*
2	1.32	7	1.20	12	0.96		
3	1.27	8	1.07	13	0.79		
4	1.28	9	1.13	14	0.60		

No. 54, *taken June* 6.

Distance out from east base, 885 feet.

ight of surface of water above Hartford zero	feet..	42.07
an in vertical plane by observed velocities	feet per second..	0.98
an velocity in vertical plane by integration	feet per second..	1.03
an velocity of river	feet per second..	1.75

)irection and force of wind, southwest, 1.

th.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
	1.06	4	0.94	8	1.10	12	0.70
	0.84	5	1.15	9	0.98	12.4	0.46*
	1.07	6	1.09	10	1.05		
	1.14	7	1.13	11	0.64		

CURRENT OBSERVATIONS AT POSITION G.

Current-meter No. 2.

No. 55, *taken July* 24.

Distance out from east base, 238 feet.

t of surface of water above Hartford zero	feet..	40.445
in vertical plane by observed velocities	feet per second..	0.43
velocity in vertical plane by integration	feet per second..	0.50
velocity of river	feet per second..	0.79

ction and force of wind, southwest, 1.

Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0.47	5	0.59	10	0.47	15	
0.44	6	0.60	11		16	
0.42	7	0.56	12		16.2	0.17
0.38	8	0.54	13	0.40	16.6	0.13*
0.47	9	0.49	14			

No. 56, *taken July* 24.

Distance out from east base, 252 feet.

t of surface of water above Hartford zero	feet..	40.445
in vertical plane by observed velocities	feet per second..	0.78
velocity in vertical plane by integration	feet per second..	0.83
velocity of river	feet per second..	0.79

ction and force of wind, southwest, 1.

Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0.63	5	0.88	10	0.82	15	0.66
0.70	6	0.93	11	0.77	16	0.62
0.72	7	0.92	12	0.77	17	0.57
0.81	8	0.87	13	0.78	17.5	0.54*
0.88	9	0.80	14	0.78		

No. 57, taken July 24.

Distance out from east base, 454 feet.

Height of surface of water above Hartford zero	feet..	40.44
Mean in vertical plane by observed velocities	feet per second..	0.92
Mean velocity in vertical plane by integration	feet per second..	0.78
Mean velocity of river	feet per second..	0.79

Direction and force of wind, southwest, 1.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	0.80	5	1.05	10	1.03	15	0.70
1	0.86	6	1.07	11	1.00	16	0.68
2	0.91	7	1.11	12	0.92	16.9	0.61
3	0.95	8	1.05	13	0.91	17.3	0.57*
4	1.03	9	1.00	14	0.85		

No. 58, taken July 23.

Distance out from east base, 544 feet.

Height of surface of water above Hartford zero	feet..	40.71
Mean in vertical plane by observed velocities	feet per second..	1.1[illegible]
Mean velocity in vertical plane by integration	feet per second..	1.07
Mean velocity of river	feet per second..	0.8[illegible]

Direction and force of wind, northwest, 1.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	0.75	5	1.32	10	1.18	15	1.05
1	0.92	6	1.28	11	1.06	16	0.82
2	1.04	7	1.25	12	1.08	16.1	0.80
3	1.08	8	1.19	13	1.06	16.5	0.69*
4	1.33	9	1.24	14	1.06		

No. 59, taken July 23.

Distance out from east base, 638 feet.

Height of surface of water above Hartford zero	feet..	40.71
Mean in vertical plane by observed velocities	feet per second..	1.1[illegible]
Mean velocity in vertical plane by integration	feet per second..	1.1[illegible]
Mean velocity of river	feet per second..	0.8[illegible]

Direction and force of wind, northwest, 1.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	1.23	5	1.29	10	1.17	15	0.69
1	1.31	6	1.28	11	1.05	15.1	0.71
2	1.37	7	1.18	12	1.00	15.5	0.64*
3	1.29	8	1.15	13	0.95		
4	1.30	9	1.17	14	0.85		

No. 60, taken July 23.

Distance out from east base, 747 feet.

Height of surface of water above Hartford zero	feet	40.715
Mean in vertical plane by observed velocities	feet per second	1.21
Mean velocity in vertical plane by integration	feet per second	1.23
Mean velocity of river	feet per second	0.89

Direction and force of wind, calm.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	1.25	4	1.32	8	1.23	12	1.04
1	1.39	5	1.34	9	1.23	13	1.01
2	1.40	6	1.31	10	1.14	13.9	0.77
3	1.36	7	1.23	11	1.10	14.3	0.62*

No. 61, taken July 22.

Distance out from east base, 835 feet.

Height of surface of water above Hartford zero	feet	40.883
Mean in vertical plane by observed velocities	feet per second	1.26
Mean velocity in vertical plane by integration	feet per second	1.25
Mean velocity of river	feet per second	0.96

Direction and force of wind, calm.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	0.99	4	1.37	8	1.35	12	1.14
1	1.08	5	1.42	9	1.40	13	1.00
2	1.10	6	1.49	10	1.25	13.4	1.06
3	1.33	7	1.40	11	1.21	13.7	0.98*

No. 62, taken July 22.

Distance out from east base, 942 feet.

Height of surface of water above Hartford zero	feet	40.883
Mean in vertical plane by observed velocities	feet per second	0.94
Mean velocity in vertical plane by integration	feet per second	0.94
Mean velocity of river	feet per second	0.96

Direction and force of wind, north-northwest, 2.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	0.75	4	1.06	8	0.93	11.2	0.68*
1	0.98	5	1.01	9	0.82		
2	1.04	6	0.99	10	0.79		
3	1.09	7	0.98	10.9	0.61		

No. 63, *taken July* 22.

Distance out from east base, 1,050 feet.

Height of surface of water above Hartford zero.....feet.. 40.8
Mean in vertical plane by observed velocities.....feet per second.. 0.7
Mean velocity in vertical plane by integration.....Not take
Mean velocity of river.....feet per second.. 0.9

Direction and force of wind, north, 2.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	0.82	3	0.79	6	0.62	8.1	0.35*
1	0.84	4	0.76	7	0.51		
2	0.82	5	0.73	7.8	0.40		

No. 64, *taken July* 22.

Distance out from east base, 1,140 feet.

Height of surface of water above Hartford zero.....feet.. 40.8
Mean in vertical plane by observed velocities.....feet per second.. 0.4
Mean velocity in vertical plane by integration.....Not take
Mean velocity of river.....feet per second.. 0.9

Direction and force of wind, north, 2.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	0.60	2	0.56	4	0.44	5.5	0.00
1	0.61	3	0.52	5	0.30	6.3	0.05*

No. 65, *taken July* 25.

Distance out from east base, 627 feet.

Height of surface of water above Hartford zero.....feet.. 40.2
Mean in vertical plane by observed velocities.....feet per second.. 0.8
Mean velocity in vertical plane by integration.....feet per second.. 0.9
Mean velocity of river.....feet per second.. 0.6

Direction and force of wind, south-southwest, 2.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	0.96	5	1.00	10	0.87	15	0.64
1	0.84	6	0.99	11	0.83	15.4	0.61*
2	0.95	7	0.97	12	0.78		
3	0.98	8	0.94	13	0.74		
4	0.99	9	0.95	14	0.66		

No. 66, taken July 25.

Distance out from east base, 938 feet.

Height of surface of water above Hartford zero	feet..	40.226
Mean in vertical plane by observed velocities	feet per second..	0.82
Mean velocity in vertical plane by integration	feet per second..	0.77
Mean velocity of river	feet per second..	0.65

Direction and force of wind, south-southwest, 1.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	0.82	4	0.92	8	1.06	11.5	0.17*
1	0.88	5	0.86	9	0.76		
2	0.94	6	0.86	10	0.67		
3	0.92	7	0.84	11	0.31		

No. 67, taken July 28.

Distance out from east base, 330 feet.

Height of surface of water above Hartford zero	feet..	39.834
Mean in vertical plane by observed velocities	feet per second..	0.58
Mean velocity in vertical plane by integration		Not taken.
Mean velocity of river	feet per second..	0.51

Direction and force of wind, southwest, 2.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	0.54	5	0.72	10	0.62	15	0.44
1	0.62	6	0.71	11	0.54	16	0.43
2	0.66	7	0.70	12	0.50	17	0.18
3	0.73	8	0.68	13	0.52	17.4	0.06*
4	0.74	9	0.65	14	0.49		

No. 68, taken July 28.

Distance out from east base, 646 feet.

Height of surface of water above Hartford zero	feet..	39.834
Mean in vertical plane by observed velocities	feet per second..	0.65
Mean velocity in vertical plane by integration	feet per second..	0.74
Mean velocity of river	feet per second..	0.51

Direction and force of wind, southwest, 3.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	0.77	5	0.74	10	0.66	14.5	0.20
1	0.75	6	0.69	11	0.60	14.9	0.00*
2	0.63	7	0.70	12	0.58		
3	0.71	8	0.68	13	0.56		
4	0.71	9	0.70	14	0.44		

No. 69, taken July 28.

Distance out from east base, 908 feet.

Height of surface of water above Hartford zero.....feet..
Mean in vertical plane by observed velocities.....feet per second..
Mean velocity in vertical plane by integration.....feet per second..
Mean velocity of river.....feet per second..

Direction and force of wind, southwest, 3.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed ity per se
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	0.60	4	0.52	8	0.58	10.9	0.34
1	0.54	5	0.56	9	0.36		
2	0.50	6	0.57	10	0.50		
3	0.48	7	0.58	10.5	0.43		

No. 70, taken June 25.

Distance out from east base, 1,059 feet.

Height of surface of water above Hartford zero.....feet.. 41
Mean in vertical plane by observed velocities.....feet per second.. 1.
Mean velocity in vertical plane by integration.....feet per second.. 0
Mean velocity of river.....feet per second.. 1

Direction and force of wind, west-northwest, 1 to 2.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed ity per se
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet*
0	1.38	3	1.12	6	0.98	8.1	0.5
1	1.23	4	1.10	7	0.85	8.4	0.4
2	1.20	5	1.01	8	0.67		

No. 71, taken June 25.

Distance out from east base, 1,161 feet.

Height of surface of water above Hartford zero.....feet.. 41
Mean in vertical plane by observed velocities.....feet per second.. 0
Mean velocity in vertical plane by integration.....feet per second.. 0
Mean velocity of river.....feet per second.. 1

Direction and force of wind, calm.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed ity per se
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet*
0	0.75	2	0.81	4	0.68	5.5	0.3
1	0.77	3	0.77	5	0.52	5.8	0.1

No. 72, taken June 23.

Distance out from east base, 158 feet.

Height of surface of water above Hartford zero.....feet.. 42.59
Mean in vertical plane by observed velocities.....feet per second.. 0.98
Mean velocity in vertical plane by integration..... Not taken.
Mean velocity of river.....feet per second.. 1.84

Direction and force of wind, southwest, 1 and 2.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	1.03	4	1.08	8	0.98	10.9	0.40*
1	1.08	5	1.18	9	0.69		
2	1.18	6	1.08	10	0.69		
3	1.18	7	0.98	10.5	0.56		

No. 73, taken June 23.

Distance out from east base, 242 feet.

Height of surface of water above Hartford zero.....feet..42.59
Mean in vertical plane by observed velocities.....feet per second.. 1.37
Mean velocity in vertical plane by integration.....feet per second.. 1.52
Mean velocity of river.....feet per second.. 1.84

Direction and force of wind, southwest, 1.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	1.37	6	1.57	12	1.28	18	1.08
1	1.47	7	1.57	13	1.28	18.7	0.62
2	1.67	8	1.47	14	1.28	19.1	0.43*
3	1.67	9	1.37	15	1.28		
4	1.67	10	1.67	16	1.28		
5	1.57	11	1.47	17	0.98		

No. 74, taken June 23.

Distance out from east base, 366 feet.

Height of surface of water above Hartford zero.....feet.. 42.59
Mean in vertical plane by observed velocities.....feet per second.. 1.69
Mean velocity in vertical plane by integration.....feet per second.. 1.65
Mean velocity of river.....feet per second.. 1.84

Direction and force of wind, west, 1 and 2.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	1.67	6	2.06	12	1.77	18	1.28
1	1.77	7	1.67	13	1.57	19	1.28
2	1.96	8	1.77	14	1.67	20	0.88
3	2.06	9	1.96	15	1.67	20.4	0.67*
4	1.96	10	1.86	16	1.57		
5	1.96	11	1.86	17	1.37		

No. 75, taken June 23.

Distance out from east base, 485 feet.

Height of surface of water above Hartford zero.....feet.. 42.59
Mean in vertical plane by observed velocities.....feet per second.. 1.98
Mean velocity in vertical plane by integration.....feet per second.. 1.98
Mean velocity of river.....feet per second.. 1.84

Direction and force of wind, west, 2.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	1.91	6	2.20	12	2.06	18	1.57
1	2.06	7	2.11	13	2.01	18.9	1.42
2	2.25	8	2.01	14	1.91	19.3	1.24*
3	2.40	9	2.11	15	1.91		
4	2.20	10	2.25	16	1.72		
5	2.20	11	1.96	17	1.77		

METER-OBSERVATIONS AT POSITION G.

Current-meter, No. 1.

No. 76, taken June 20.

Distance out from east base, 600 feet.

Height of surface of water above Hartford zero.....feet.. 43.69
Mean in vertical plane by observed velocities.....feet per second.. 2.30
Mean velocity in vertical plane by integration.....feet per second.. 2.61
Mean velocity of river.....feet per second.. 2.05

Direction and force of wind, northeast, 2.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	2.57	6	2.51	12	2.26	18	1.53
1	2.54	7	2.50	13	2.17	18.6	1.50*
2	2.56	8	2.44	14	2.25	19	1.32
3	2.71	9	2.63	15	2.02		
4	2.64	10	2.48	16	1.67		
5	2.54	11	2.09	17	2.07		

No. 77, taken June 20.

Distance out from east base, 694 feet.

Height of surface of water above Hartford zero.....feet.. 43.6
Mean in vertical plane by observed velocities.....feet per second.. 2.2
Mean velocity in vertical plane by integration.....feet per second.. 2.3
Mean velocity of river.....feet per second.. 2.0

Direction and force of wind, northeast, 1.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	2.49	5	2.54	10	2.38	15	2.00
1	2.54	6	2.50	11	2.35	16	1.80
2	2.59	7	2.50	12	2.24	17	1.44
3	2.68	8	2.52	13	2.08	17.5	1.27
4	2.55	9	2.39	14	2.14	18	0.97*

No. 78, taken June 19.

Distance out from east base, 796 feet.

Height of surface of water above Hartford zero	feet..	42.73
Mean in vertical plane by observed velocities	feet per second..	2.14
Mean velocity in vertical plane by integration	feet per second..	2.16
Mean velocity of river	feet per second..	1.53

Direction and force of wind, north, 1.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	2.18	5	2.30	10	2.23	15	1.84
1	2.14	6	2.41	11	2.12	15.4	1.52
2	2.32	7	2.21	12	2.06	15.8	1.09*
3	2.37	8	2.24	13	2.02		
4	2.19	9	2.17	14	1.96		

No. 79, taken June 19.

Distance out from east base, 891 feet.

Height of surface of water above Hartford zero	feet..	42.73
Mean in vertical plane by observed velocities	feet per second..	1.92
Mean velocity in vertical plane by integration	feet per second..	1.99
Mean velocity of river	feet per second..	1.63

Direction and force of wind, north, 1.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	2.10	4	2.04	8	1.95	12	1.81
1	1.99	5	2.18	9	1.81	13	1.75
2	2.14	6	2.19	10	1.75	14	1.50
3	2.14	7	2.05	11	1.73	14.4	1.24*

No. 80, taken June 19.

Distance out from east base, 972 feet.

Height of surface of water above Hartford zero	feet..	42.73
Mean in vertical plane by observed velocities	feet per second..	1.49
Mean velocity in vertical plane by integration	feet per second..	1.51
Mean velocity of river	feet per second..	1.63

Direction and force of wind, north-northeast, 2 and 3.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	1.70	4	1.77	8	1.43	11.9	0.82
1	1.63	5	1.75	9	1.51	12.3	0.46*
2	1.80	6	1.57	10	1.32		
3	1.80	7	1.47	11	1.27		

No. 81, *taken June* 18.

Distance out from east base, 1,081 feet.

Height of surface of water above Hartford zero.....feet.. 42.7
Mean in vertical plane by observed velocities.....feet per second.. 1.2
Mean velocity in vertical plane by integration.....feet per second.. 1.3
Mean velocity of river.....feet per second.. 1.6

Direction and force of wind, northeast, 3 and 4.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	1.48	3	1.44	6	1.10	8.1	0.53
1	1.41	4	1.27	7	1.20	8.5	0.30*
2	1.55	5	1.28	8	0.84		

No. 82, *taken June* 18.

Distance out from east base, 1,184 feet.

Height of surface of water above Hartford zero.....feet.. 42.083
Mean in vertical plane by observed velocities.....feet per second.. 0.27
Mean velocity in vertical plane by integration.....feet per second.. 0.34
Mean velocity of river.....feet per second.. 1.41

Direction and force of wind, northwest, 4.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	0.59	2	0.44	4.0	0.0	4.7	0.0*
1	0.44	3	0.00	4.3	0.0		

METER-OBSERVATIONS AT POSITION G.

Current-meter, No. 2.

No. 83, *taken June* 24.

Distance out from east base, 1,059 feet.

Height of surface of water above Hartford zero.....feet.. 42.0
Mean in vertical plane by observed velocities.....feet per second.. 1.1
Mean velocity in vertical plane by integration.....feet per second.. 1.1
Mean velocity of river.....feet per second.. 1.6

Direction and force of wind, northwest, 3.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	1.33	3	1.28	6	1.03	9.6	0.56
1	1.37	4	1.23	7	1.03	9	0.28*
2	1.37	5	1.18	8	0.88		

No. 84, taken June 24.

Distance out from east base, 1,172 feet.

Height of surface of water above Hartford zero	feet..	42.09
Mean in vertical plane by observed velocities	feet per second..	0.76
Mean velocity in vertical plane by integration	feet per second..	0.69
Mean velocity of river	feet per second..	1.62

Direction and force of wind, northwest, 2 and 3.

Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.	Depth.	Observed velocity per second.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	0.93	3	0.78	6.0	0.64		
1	0.95	4	0.84	6.1	0.59		
2	0.88	5	0.64	6.5	0.45*		

These curves have all been plotted, as shown on the sheets transmitted. They have also been combined and reduced in several groups, by taking the means of the velocities at tenths of the total depth, for the purpose of ascertaining the general laws and forms of the several curves.

The means at the surface and tenths of the depth, as plotted in figures 1 to 9 inclusive, of the accompanying diagram, are shown in the following table. The other figures are obtained either from these or by graphic methods, as before described.

Whenever there was doubt about the proper operation of the current-meter, or where the bottom-velocities were smaller than could be correctly measured by it, and also where the floats did not run within 2 feet from the bottom, the whole curve has been rejected from the following means. The varying mean velocities of the several planes require that an equal number of velocities at each depth should be combined to give proper mean results. For this reason numbers 1, 2, 11, and 20 of the float-observations, and numbers 13, 14, 24, 38, 39, 59, and 82 of the meter-observations, have been omitted in the following mean curves:

Table of ordinates of mean-velocity curves taken at tenths of the depth from surface to bottom.

Fig. 1, Fig. 2, &c., refers to plotted diagrams.	Surface.	1.	2.	3.	4.	5.	6.	7.	8.	9.	Bottom.	Mean.
Mean of meter-observations below average velocity of 1.86 (Fig. 1)	1.15	1.19	1.22	1.22	1.19	1.14	1.11	1.03	0.94	0.79	0.46	1.063
Mean of float-observations below average velocity of 1.86 (Fig. 2)	1.50	1.52	1.52	1.53	1.49	1.46	1.35	1.29	1.20	0.97	0.58	1.337
Mean of all observations below average velocity of 1.86 (Fig. 3)	1.21	1.25	1.27	1.27	1.24	1.19	1.15	1.07	0.99	0.82	0.48	1.109
Mean of meter-observations above average velocity of 1.86 (Fig. 4)	2.96	3.08	3.12	3.06	2.99	2.91	2.78	2.62	2.42	2.16	1.47	2.735
Mean of float-observations above average velocity of 1.86 (Fig. 5)	3.26	3.24	3.17	3.17	3.11	3.01	2.94	2.80	2.60	2.33	1.78	2.891
Mean of all observations above average velocity of 1.86 (Fig. 6)	3.01	3.11	3.13	3.08	3.01	2.93	2.81	2.65	2.45	2.20	1.53	2.764
Mean of all meter-observations (Fig. 7)	2.05	2.12	2.15	2.13	2.08	2.01	1.93	1.81	1.67	1.47	0.96	1.887
Mean of all float-observations (Fig. 8)	2.38	2.38	2.35	2.35	2.30	2.23	2.15	2.04	1.90	1.66	1.18	2.114
Mean of all meter and float observations (Fig. 9)	2.10	2.17	2.19	2.17	2.12	2.05	1.97	1.85	1.71	1.50	1.00	1.928

MEAN-VELOCITY RATIOS.

The ratios between the mean velocity and the velocity at half-depth, and the ratio of the depth of the thread of mean velocity to the whole depth, in the curves obtained by the method of numerical means, are shown in the following table.

These values are determined from straight lines joining the given points as computed, without attempting to draw an approximate curve through them.

The system of nomenclature used is the same as that of the Mississippi report.

$V_{\frac{1}{2}D}$ = velocity at half-depth.

V_m = mean velocity in vertical plane.

m = depth of thread of mean velocity.

D = total depth.

Table of mean-velocity ratios.

	$\frac{V_{\frac{1}{2}D}}{V_m}$	$\frac{V_m}{V_{\frac{1}{2}D}}$	$\frac{m}{D}$
Meters at low velocities	1.072	.933	
Floats at low velocities	1.090	.918	
Mean at low velocities	1.076	.930	
Meters at high velocities	1.065	.939	
Floats at high velocities	1.040	.961	
Mean at high velocities	1.060	.944	
Mean by meters	1.067	.937	
Mean by floats	1.056	.947	
Grand mean	1.064	.940	

NOTE.—The "means" given above are not obtained by combining the results of f and meter observations in this table, but are an independent determination di from the observations of which those with the meter were greatly in excess.

TABLE OF HEIGHTS AND SLOPES.

The following table shows the height, slopes, and mean velocities of the rive observed during the progress of the experiments. Gauges were read at the point dicated, and the differences are shown in the tables; these differences being alv additive up the river between the points named. All the gauges were upon the bank of the river.

Gauge V was upon the bank of the river at Thompsonville, 480 feet below the tion marked C on the map.

Gauge C was at the section C, just above the ferry at Thompsonville.

Gauge B was at the section B, 2,280 feet above section C.

Gauge U was at position G or F, which lines were only 100 feet apart, and there no appreciable slope between them. G is 1,650 feet above B.

Gauge T was upon the bank of the river, 2,970 feet above position G.

Gauge M was upon the bank of the river, 6,200 feet above position G.

Levels were taken between the gauges on the east bank of the river and carel tested. An 18-inch Gurley level was used, and the leveling was at first unsatisfact a more sensitive bubble was placed in the instrument and the construction of the eral parts examined. A slight difference of diameter in the collars resting in th was discovered, causing the line of sight to look up when adjusted in the usual r ner. It was therefore adjusted by the "Gravatt" method and tested with a coll tor. The levels were then taken with more accurate results.

Between the extreme gauges V and M, a distance of about two miles, the prob error of the levels is $\pm$.006 of a foot.

From V to B the probable error is $\pm$ .003.

From V to U the probable error is $\pm$ .004.

From U to T the probable error is $\pm$ .005.

From U to M the probable error is $\mp$ .005.

The error is not proportional to the distance between the ganges as the levels v not taken directly upon the bank, but were connected with bench-marks at some tance back. The probable errors for each chain of levels are computed by taking square root of the sum of the squares of the errors between intermediate points.

The above quantities do not include the errors of observation in comparing heights of water with the gauges. The practical difficulty of this comparison on count of the motion of the water, even when taken in a box-gauge, is such as to der the probable errors of difference of heights given in the following table n greater than those for the levels given above. Their amount cannot be exactly mated.

A list of the bench-marks used near the gauges is also given, with their height feet above the base, or low-water mark at Hartford.

Table showing heights of Connecticut River near Thompsonville, Conn., 1874.

[The numbers in columns 5 to 11 are the observed differences of height in feet by gauges.]

Date.	Place.	Height of water.	Mean velocity per second.	V to C, 480 feet.	V to B, 2,760 feet.	B to U, 1,650 feet.	V to U, 4,410 feet.	C to U, 3,930 feet.	U to T, 2,970 feet.	U to M, 6,200 feet.
		Feet.	*Feet.*							
May 6	F	43.990	2.44	.....	.....	.....	0.532	.....	.....	.....
7	F	44.160	2.57	.....	.....	.....	0.550	.....	.....	.....
9	F	43.500	2.08	.....	.....	.....	0.465	.....	0.048	.....
12	F	45.213	2.87	.....	.....	.....	.....	.....	0.146	.....
13	F	44.508	2.53	.....	.....	.....	.....	.....	.....	.....
14	F	44.237	2.34	.....	.....	.....	.....	.....	.....	.....
15	F	43.467	2.06	.....	.....	.....	.....	.....	.....	.....
20	F	44.782	2.67	.....	.....	.....	0.626	.....	.....	.....
22	F	45.484	3.01	.....	.....	.....	0.667	.....	0.234	.....
23	F	45.829	3.08	.....	.....	.....	0.646	.....	0.203	.....
26	F	45.217	2.89	.....	.....	.....	.....	.....	.....	.....
27	F	44.884	2.70	.....	.....	.....	.....	.....	.....	.....
28	B	44.300	3.50	.....	0.378	.....	0.557	.....	0.168	.....
29	B	43.666	3.21	.....	0.317	0.177	0.494	.....	0.108	.....
June 1	B	42.277	2.56	.....	.....	.....	0.545	0.489	0.146	.....
2	C	42.387	1.87	0.041	.....	.....	0.476	0.434	0.108	.....
3	C	42.290	1.81	0.037	.....	.....	0.453	0.415	0.100	.....
6	C	42.070	1.75	.....	.....	.....	0.458	.....	0.051	.....
9	G	43.097	1.80	.....	.....	.....	0.478	.....	0.129	.....
10	G	42.747	1.70	.....	.....	.....	0.447	.....	0.123	.....
12	G	41.631	1.30	.....	.....	.....	0.302	.....	0.072	.....
15	G	41.423	1.17	.....	.....	.....	0.277	.....	0.042	.....
16	G	41.323	1.14	.....	.....	.....	0.285	.....	0.035	.....
18	G	42.083	1.41	.....	.....	.....	0.337	.....	0.086	.....
19	G	42.730	1.63	.....	.....	.....	0.417	.....	0.093	.....
20	G	43.690	2.05	.....	.....	.....	0.531	.....	0.078	.....
23	G	42.590	1.84	.....	.....	.....	0.396	.....	0.091	.....
24	G	42.090	1.62	.....	.....	.....	0.347	.....	0.078	.....
25	G	41.640	1.38	.....	.....	.....	0.314	.....	0.072	.....
July 14	G	44.411	.....	.....	0.381	0.197	0.578	.....	.....	.....
15	G	43.415	.....	.....	0.297	0.199	0.499	.....	.....	.....
16	G	42.507	.....	.....	0.233	0.129	0.362	.....	.....	0.223
17	G	41.834	.....	.....	0.180	0.123	0.313	.....	.....	0.104
22	G	40.883	0.96	.....	.....	.....	0.210	.....	.....	0.084
23	G	40.715	0.89	.....	.....	.....	0.199	.....	.....	0.089
24	G	40.445	0.79	.....	.....	.....	0.162	.....	.....	0.090
25	G	40.226	0.65	.....	.....	.....	0.159	.....	.....	0.075
28	G	39.834	0.51	.....	.....	.....	0.156	.....	.....	0.037
Sept. 2	G	39.160	0.51	.....	.....	.....	0.096	.....	.....	0.050
3	G	39.113	.....	.....	.....	.....	0.111	.....	.....	0.000
4	G	39.078	.....	.....	.....	.....	0.093	.....	.....	0.032
5	G	38.980	0.34	.....	.....	.....	0.073	.....	.....	0.031

LIST OF BENCH-MARKS NEAR GAUGES AT THOMPSONVILLE, CONN.

Bench-mark near gauge V:

Southwest corner of second stone from ground at south end, west side of south abutment of road-bridge, west of first culvert south of Thompsonville station. 48.964

Bench-mark near gauge B:

Cut in first of two small chestnut-trees, on east bank Connecticut River, 28 feet west of station 930 ..... 66.759

Bench-mark near gauge U:

On east side of north one of three ash-trees on bank of Connecticut River, near section No. 1, position F 50.167

Bench-mark near gauge T:

On south side of maple-tree, on line with fence due west from bench-mark No. 6 ..... 47.619

Bench-mark near gauge M:

60 feet from river-bank and about 300 feet north of Longmeadow Brook, cut and copper tack near bottom in north side of apple-tree 49.708

TABLES OF AREAS AND WIDTHS OF CROSS-SECTIONS.

The following tables give the mean areas and surface-widths of cross-sections of the river at places where current-observations were made. These are computed for each foot in height, and proportional parts of the differences may be taken for intermediate fractions of a foot.

At B and C one section only was computed, as meters only were used at those places for determining the velocities.

At F and G the mean areas given are the means of five sections, 50 feet apart, embracing the 200 feet over which floats were run. The mean areas from U to T, and from U to M, are the mean sections of the river for the whole distance between those points, as determined from cross-sections 400 feet apart. The heights of the water above Hartford base being given in even feet at the lower end at U, or on the section G. In computing these areas allowance has been made for the varying slope of the surface at different stages.

Table showing mean areas of cross-sections of Connecticut River at Thompsonville, Conn.

Places.	38′	39′	40′	41′	42′	43′	44′	45′	46′
Area at position C.....	11,275	12,241	13,225	14,233	15,258	16,297	17,348	18,410	19,482
Area at position B.....	4,400	5,776	7,163	8,561	9,964	11,376	12,792	14,210	15,640
Mean area at position F....	11,212	12,308	13,433	14,576	15,737	16,908	18,088	19,272	20,464
Mean area at position G....	11,493	12,601	13,735	14,890	16,062	17,245	18,437	19,633	20,838
Mean area from U to T....	11,276	12,439	13,620	14,812	16,024	17,232	18,455	19,682	20,912
Mean area from U to M....	10,411	11,654	12,985	14,352	15,677	17,006	18,345	19,690	21,040

NOTE.—The areas are in square feet below the heights at the heads of the columns.

Table showing surface-widths of cross-sections of Connecticut River at Thompsonville, Conn.

Places.	38′	39′	40′	41′	42′	43′	44′	45′	46′
Width at position C.....	963	972	999	1,017	1,031	1,046	1,057	1,068	1,0[illegible]
Width at position B.....	1,367	1,382	1,391	1,400	1,409	1,412	1,415	1,417	1,4[illegible]
Width at position F.....	1,105	1,123	1,144	1,160	1,176	1,183	1,187	1,190	1,1[illegible]
Width at position G.....	1,118	1,135	1,152	1,165	1,178	1,190	1,196	1,201	1,2[illegible]
Mean width from U to T...	1,154	1,161	1,176	1,185	1,196	1,206	1,212	1,216	1,2[illegible]
Mean width from U to M..	1,248	1,260	1,275	1,285	1,297	1,306	1,312	1,318	1,3[illegible]

NOTE.—The widths are given in feet at the heights shown at the heads of the columns.

METHODS OF COMPUTING THE DISCHARGE.

The method adopted for computing the discharge at Thompsonville, for the observations at all depths, was as follows: The mean velocity in each vertical section was taken at equal distances across the river so as to divide the cross-section into divisions of equal width with the observed section in the middle of each division.

When the positions of the observed sections varied materially from their proper distances apart, the mean velocities were plotted on section-paper as ordinates, at their true distance from the base, and a free-hand curve drawn through them, from which velocities at the proper intervals were taken.

Each mean velocity of the vertical sections was then multiplied by the actual depth at the place, and the sum of these products divided by the sum of the depths. This gave the mean velocity of the river, as each local velocity had given to it its proper weight proportional to the area it represented. This mean velocity was then multiplied by the total area of the cross-section of the river to give the discharge. This method of computing gives theoretically a slightly too small quantity, but practically the error is immaterial, being very much within the amount of errors of observation. The discharge of a stream in feet per second may be represented by a solid, which has for its base the cross-section of the stream in square feet, for its sides the surface and bottom of the water, and for its top the curved surface bounded by the ends of the ordinates representing the velocity in feet per second of each filament of the current. In order, therefore, to obtain the exact discharge, we have in some way to compute the contents of this solid. If the bottom were straight lines between the sections taken, probably the best method of computation would be by the prismoidal formula, with the vertical sections as bases; or, if the bottom were a regular curve, represented by

he depths taken as ordinates, the application of Simpson's rule to the areas of the ctions would give a very close approximation to the true contents. The bottom, owever, in the cross-sections computed was not shown with sufficient accuracy by e depths at 100-foot distances, so that the method before described was adopted, hich is equivalent to taking the mean height of the solid and multiplying by the se. The reason of its giving a slightly too small value theoretically is that this ethod assumes that the horizontal-velocity curves are a succession of straight lines om point to point between the sections; but this involves a much smaller error than pposing the bottom straight from point to point, as in the application of the pris-oidal formula.

When the discharge was determined from middepth observations, the same general ethod was adopted. The middepth velocities were each multiplied by the depth, d the sum of the products divided by the sum of the depths. The velocity obtained as then multiplied by the ratio of the mean velocity to the middepth velocity as termined by the mean-vertical velocity curves for this river at the place observed.

During the continuance of the observations upon a number of vertical sections across e river, the height of the water would sometimes remain nearly uniform, but would other times vary several tenths of a foot during the experiments. In all cases a ean height of water was taken, and the mean velocities corrected when necessary. he succession of observations at the same place gave the proportional differences of rrection. They were generally small and for but few velocities in any cross-section.

The two following tables give results of the calculations for discharges at Thompsonille at different stages. The results are plotted on sheet No. 14, with the heights of he water as ordinates and the computed volumes as abscissas, and on sheet No. 15 in wo curves having the dates for the abscissas, and the volumes of the river for the rdinates of one curve, and the heights of the water as the ordinates of the other curve.

Table showing the computed discharge for each day on which observations were taken at Thompsonville.

Date.	Station.	Number of observations.	Force and direction of wind.	Height of water at G.	Area of section, square feet.	Mean velocity per second.	Discharge per second.
						Feet.	*Cu. feet.*
May 6	F	F 57	S., 1	43.99	18,077	2.443	44,163
7	F	F 37	N., 3	44.16	18,277	2.570	46,973
9	F	F 23	S., 1 to 2	43.50	17,498	2.083	36,448
12	F	F & M, 46	S. E., 1 to 2	45.21	19,522	2.87	56,028
13	F	F & M, 62	S. E., 1, to S., 1	44.51	18,692	2.55	47,665
14	F	M 21	N. W., 1	44.24	18,656	2.34	43,655
15	F	F 20	S. E., 0 to 2	43.47	17,463	2.06	36,974
20	F	F & M, 40	S. E., 1, to S. W., 3	44,78	19,012	2.67	50,762
22	F	F & M, 41	N. W., 2 to 4	45.48	19,844	3.01	59,730
23	F	M 21	Calm	45.83	20,546	3.08	63,282
26	F	F & M, 52	S. W., 1, to N. W., 2	45.22	19,534	2.89	56,453
27	F	F & M, 41	N. W., 1	44.88	19,130	2.70	51,651
28	B	M 76	N. W., 3, to S. W., 2	44.48	13,217	3.50	46,259
29	B	M 41	N. W., 1, to S. W., 1	43.85	12,325	3.21	39,563
June 1	B	M 10	Calm	42.46	10,359	2.56	26,519
2	C	M 125	N. W., 1 to 0	42.82	15,663	1.87	29,290
3	C	M 66	S. W., 3, to S. E., 2	42.70	15,559	1.81	28,162
6	C	M 86	S. W., 0 to 1	42.48	15,331	1.75	26,829
9	G	F & M, 26	S. W., 2 to 0	43.10	17,364	1.80	31,255
10	G	M 58	N., 1 to 0	42.75	17,557	1.70	29,847
12	G	F 26	N. E., 1, to S. W., 1	41.63	15,628	1.30	20,316
15	G	F & M, 66	Calm	41.42	15,382	1.17	17,997
16	G	F & M, 56	S. E., 2 to 4	41.32	15,265	1.14	17,402
18	G	M 47	N. W., 4 to 5	42.08	16,765	1.41	23,639
19	G	M 55	N. W., 1, to N. E., 4	42.73	17,533	1.63	28,579
20	G	M 39	N. E., 1 to 2	43.69	18,675	2.05	38,284
23	G	M 73	S. W. & W., 1 to 2	42.59	17,367	1.84	31,955
24	G	M 18	N. W., 2 to 3	42.09	16,776	1.62	27,177
25	G	F & M, 31	N. W., 2 to 0	41.64	15,640	1.38	21,583
uly 22	G	M 43	N. W., 0 to 2	40.88	15,358	.96	14,744
23	G	M 50	N. W., 1 to 0	40.71	15,162	.89	13,494
24	G	M 49	S. W., 1	40.44	14,850	.79	11,731
25	G	M 28	S. W., 2 to 1	40.23	14,608	.65	9,495
28	G	M 46	S. W., 2 to 3	39.83	14,149	.51	7,216
ept. 2	G	F 20	N., 0 to 2	39.16	12,782	.5106	6,526
5	G	F 11	Calm	38.98	12,579	.3404	4,282

NOTE.—F and M in the third column stand for floats and meters.

Table showing computed discharges at Thompsonville, where velocities were observed in each division.

Date.	Station.	Manner of gauging.	Number of observations.	Mean height of water at G.	Width at surface.	Area of section, square feet.	Mean division velocities, feet per second.													Mean velocity.	Discharge, cubic feet per second.
							1	2	3	4	5	6	7	8	9	10	11	12	13	14	
May 6	F	Floats at one-half mean depth.	57	43.99	1,187	18,077	1.76	2.20	2.54	2.73	2.86	3.00	2.98	2.87	2.73	2.37	1.93	1.35	.....	.....	2.443	44,163
May 7	F	.....do	37	44.16	1,188	18,277	1.84	2.32	2.69	2.72	2.94	3.21	2.97	2.88	2.88	2.61	2.16	1.61	.....	.....	2.570	46,973
May 9	F	.....do	23	43.50	1,185	17,498	1.44	1.93	2.23	2.36	2.50	2.60	2.55	2.58	2.34	1.99	1.50	.98	.....	.....	2.083	36,448
May 12–27	F	Meter No. 1 at all depths	194	45.03	1,190	19,308	2.38	2.72	2.39	2.48	2.75	2.94	2.91	2.96	3.05	2.63	2.32	.....	.....	.....	2.701	52,151
May 12–27	F	Floats at all depths.....	130	45.00	1,190	19,260	2.47	2.84	2.82	2.71	2.78	2.91	3.08	3.18	3.03	3.00	2.66	2.16	.....	.....	2.855	54,987
May 28 to June 1	B	Meter No. 1 at all depths	127	44.18	1,415	12,792	2.80	3.48	3.53	3.68	3.65	3.63	3.93	4.00	3.84	3.54	3.35	3.06	2.54	2.18	3.392	43,390
June 2–3	C	.....do	191	42.77	1,035	15,622	.87	1.74	2.60	2.69	2.07	1.68	1.41	1.19	.72	.....	.....	.....	.....	.....	1.853	28,948
June 9–18	G	.....do	181	42.15	1,180	16,239	.79	.92	1.31	1.59	1.65	1.68	1.83	1.76	1.48	1.28	.83	.....	.....	.....	1.455	23,628
June 12–25	G	Floats and meter No. 1 at all depths.	168	41.53	1,172	15,511	.71	.83	1.13	1.35	1.30	1.53	1.53	1.53	1.31	1.02	.71	.....	.....	.....	1.250	19,389
June 18–25	G	Meters Nos. 1 and 2 at all depths.	190	42.91	1,190	17,138	1.05	1.42	1.76	2.05	2.12	2.08	2.19	1.97	1.54	1.29	.45	.....	.....	.....	1.731	29,667
June 19–25	G	Meter No. 2 at all depths	163	42.10	1,179	16,180	.88	1.27	1.79	1.88	1.93	1.98	2.03	1.81	1.38	1.13	.76	.....	.....	.....	1.621	26,228
July 22–24	G	.....do	142	40.70	1,162	14,543	.24	.41	.74	.92	1.13	1.14	1.26	1.04	.78	.42	.....	.....	.....	.....	.883	12,843
Sept. 2	G	Floats at one-half depth, each section.	20	39.16	1,136	12,782	.45	.60	.63	.66	.60	.52	.51	.46	.39	.24	.....	.....	.....	.....	.5106	6,526
Sept. 5	G	.....do	11	38.98	1,136	12,579	.29	.39	.40	.40	.44	.41	.35	.29	.22	.18	.....	.....	.....	.....	.3404	4,282

REDUCING THE DISCHARGE TO HARTFORD.

In order to reduce the discharges to the gauge-readings at Hartford, where they have been taken daily, a quantity has been added to each computed discharge at Thompsonville equal to the probable volume of the streams flowing into the Connecticut between the two places.

In making this correction it has been assumed that these streams rise and fall in proportion to the height of water in the Connecticut. This is probably not correct, but it is perhaps the nearest approximation that can be obtained, and is but a small portion of the total volume of the river.

The gauging at Dividend Bar has been reduced to the discharge at Hartford by subtracting the probable volume of water entering the river between these points. In order to complete the computation of the discharge at Hartford up to the height of the greatest freshet known, which was that of 1854, when the water at Hartford rose to the height of 29.80 feet above the zero of the gauge at the toll-bridge, the greatest amount of water passing over Holyoke Dam has been computed from the greatest recorded depth and a measurement of the dam, and this added to the probable quantity running into the river from the streams between Holyoke and Hartford, has been assumed as the volume of the river at its greatest height. This is the only determination attainable of the discharge at Hartford between the height of 24 feet and 30 feet, and is made use of in the table of discharges to compute those above 24 feet in height.

The following table gives the data from which the discharge at Hartford has been computed.

The discharge at the place observed is given, with the correction applied in another column. The place and method of gauging are also given.

The height at Hartford given in this table is the mean height for the time observed at Thompsonville. For the two lowest readings of 1.87 feet and 2.05 feet, the exact averages of two high and two low tides were taken, extending over somewhat more time than the observations, but necessary to be included to obtain the mean height for the day.

Computations of discharge referred to Hartford gauge.

Place of gauging.	Date.	Gauge at Hartford.	Discharge in cubic feet per second.	Difference for intermediate streams.	Discharge at Hartford.	Method of gauging.
Thompsonville ..... G..	September 5, 1874	1.87	4,281	+ 800	5,081	Floats at half-depth at each section.
Do ..... G..	September 2, 1874	2.05	6,526	+ 900	7,426	Do.
Do ..... G..	July 22, 23, 24, 25, 28, 1874	3.59	7,643	+ 1,200	8,843	Meter No. 2 at each 1′ in depth.
Do ..... G..	July 22, 23, 24, 1874	4.88	12,843	+ 1,600	14,443	Do.
Do ..... G..	June 12, 15, 16, 18, 25, 1874	7.00	19,389	+ 2,500	21,889	Floats at each 1′ in depth.
Do ..... G..	June 9, 10, 15, 16, 18, 1874	8.00	23,628	+ 3,000	26,628	Meter No. 1 at each 1′ in depth.
Do ..... G..	June 19, 23, 24, 25, 1874	8.55	26,228	+ 3,350	29,578	Meter No. 2 at each 1′ in depth.
Do ..... G..	June 18, 19, 20, 23, 25, 1874	8.91	29,667	+ 3,600	33,267	Meters Nos. 1 and 2 at each 1′ in depth.
Do ..... C..	June 2, 3, 1874	9.60	28,948	+ 4,000	32,948	Meter No. 1 at each 1′ in depth.
Hartford Bar	April 15 and May 12, 1871	10.40	33,969	0	33,969	Meter (Woltman) half-depth at each section.
Thompsonville ..... F..	May 9, 1874	11.60	36,448	+ 5,500	41,948	Floats at half mean depth.
Do ..... F..	May 6, 1874	11.68	44,163	+ 5,600	49,763	Do.
Do ..... F..	May 7, 1874	12.87	46,973	+ 6,650	53,623	Do.
Do ..... B..	May 28, 29, June 1, 1874	13.64	43,300	+ 7,400	50,700	Meter No. 1 at each 1′ in depth.
Hartford Bar	March 16, 1871	14.30	51,355	0	51,355	Meter (Woltman) half-depth at each section.
Thompsonville ..... F..	May 12, 13, 20, 22, 26, 27, 1874	14.40	54,987	+ 8,200	63,187	Floats at each 1′ in depth.
Do ..... F..	May 12, 13, 14, 20, 22, 23, 26, 27, 1874	14.46	52,151	+ 8,300	60,451	Meter No. 1 at each 1′ in depth.
Hartford Bar	May 10, 1871	14.70	50,402	0	50,402	Meter (Woltman) half-depth at each section.
Do	May 9, 1871	17.00	61,092	0	61,092	Do.
Dividend Bar	April 12, 1872	19.65	100,919	− 2,900	98,019	Floats at half mean depth.
Do	January 10, 1874	23.87	142,094	− 4,300	137,794	Do.
Holyoke Dam	Highest water	29.83	168,918	+36,546	205,464	By Francis formula for weirs.

hese quantities have been carefully plotted on section paper, with the vertical scale resenting the height of the water at Hartford and the horizontal scale representing discharges, and a curve has been drawn which should, as nearly as possible, repre- t the mean of all the determinations for the discharge at Hartford. The following le shows the discharge, in cubic feet per second, for each foot in height as deter- ned by this curve. This of course only shows a mean discharge at the height given, e volumes at the same stage being different at different times, and generally greater a rising than a falling river. As the determinations of the quantity of actual dis- arge could not be conveniently made at Hartford, where the gauge-readings were ept, the variations of volume at the same stage under different circumstances are not nown.

Discharge of the Connecticut River at Hartford for each foot in height.

Gauge at Hartford.	Discharge per second.	Gauge at Hartford.	Discharge per second.	Gauge at Hartford.	Discharge per second.
Feet.	*Cubic feet.*	*Feet.*	*Cubic feet.*	*Feet.*	*Cubic feet.*
0	5,000	11	41,800	22	119,100
1	5,500	12	47,200	23	128,800
2	6,500	13	52,700	24	139,200
3	8,400	14	58,400	25	150,000
4	10,800	15	64,300	26	161,300
5	14,300	16	70,700	27	172,700
6	17,600	17	77,500	28	184,200
7	22,100	18	84,700	29	195,700
8	26,700	19	92,700	30	207,500
9	31,400	20	101,100		
10	36,600	21	109,800		

TOTAL DISCHARGE OF THE RIVER.

From the record which has been kept at Hartford since 1871, diagrams have been prepared for the years 1871, 1872, 1873, and 1874, showing the fluctuations of the water for those years. During most of the time the height has been taken three times daily, all of which has been plotted on the diagrams herewith submitted. Tables have also been made of the discharge each day in millions of cubic feet taken from the average heights for the day. The amounts are also given for each month and the whole year. Tables are also submitted showing the number of days in each month and year that the water was above any given height from February 1, 1871, to December 31, 1874.

Table showing the daily discharge and height of the Connecticut River at Hartford from ruary 1 to *December* 31, 1871.

Date.	Height. feet.	Millions of cubic feet.	Date.	Height. feet.	Millions of cubic feet.	Date.	Height. feet.	Millions of cubic
1871.			1871.			1871.		
			Mar. 1	12.57	4,340	May 1	8.59	
			2	12.67	4,395	2	8.22	
			3	12.74	4,414	3	7.68	
			4	12.78	4,440	4	7.30	
			5	12.80	4,449	5	11.18	
			6	12.82	4,465	6	18.05	
			7	12.87	4,440	7	18.47	
			8	12.95	4,520	8	18.35	
			9	13.05	4,570	9	17.06	
			10	13.18	4,625	10	14.60	
			11	13.32	4,696	11	12.32	
			12	13.50	4,780	12	16.16	
			13	14.18	5,140	13	9.04	
			14	16.10	6,160	14	7.88	
			15	16.16	6,180	15	7.10	
			16	14.33	5,190	16	6.61	
			17	14.00	5,025	17	6.14	
			18	13.72	4,890	18	5.50	
			19	13.48	4,775	19	5.40	
			20	13.36	4,710	20	5.00	
			21	13.30	4,690	21	4.84	
			22	13.56	4,825	22	4.72	
			23	14.37	5,220	23	4.68	
			24	13.15	4,600	24	4.60	
			25	11.30	3,750	25	4.53	
			26	11.22	3,710	26	4.64	
			27	11.22	3,710	27	4.49	
			28	7.56	2,122	28	4.41	
			29	7.00	1,920	29	4.37	
			30	6.70	1,785	30	4.16	
			31	6.44	1,686	31	4.00	
					134,328			
Feb. 1	2.77	681	Apr. 1	6.40	1,676	June 1	3.90	
2	2.70	674	2	6.47	1,700	2	3.81	
3	2.60	656	3	6.57	1,747	3	3.70	
4	2.57	653	4	6.80	1,827	4	3.60	
5	2.59	655	5	7.18	1,975	5	3.80	
6	2.66	662	6	7.33	2,030	6	3.41	
7	2.56	652	7	7.16	1,972	7	3.24	
8	2.60	656	8	7.04	1,916	8	3.01	
9	2.66	662	9	7.00	1,920	9	2.70	
10	2.78	682	10	7.03	1,115	10	2.66	
11	2.94	714	11	7.86	2,240	11	2.76	
12	3.17	752	12	8.75	2,620	12	2.86	
13	3.43	801	13	9.34	2,872	13	2.86	
14	3.68	867	14	10.35	3,325	14	1.90	
15	4.16	976	15	10.41	3,350	15	2.51	
16	4.38	1,040	16	8.75	2,620	16	2.10	
17	5.14	1,260	17	7.75	2,192	17	2.09	
18	5.74	1,456	18	7.06	1,925	18	2.52	
19	6.37	1,675	19	7.07	1,914	19	3.76	
20	7.00	1,920	20	7.16	1,972	20	5.22	
21	7.72	2,185	21	7.33	2,030	21	5.22	
22	8.38	2,445	22	8.03	2,320	22	4.68	
23	9.00	2,713	23	8.21	2,390	23	3.82	
24	10.00	3,170	24	8.33	2,435	24	3.14	
25	11.22	3,720	25	8.18	2,380	25	3.45	
26	11.18	3,698	26	8.03	2,320	26	3.76	
27	12.22	4,175	27	7.53	2,120	27	3.02	
28	12.40	4,260	28	7.58	2,130	28	2.76	
			29	8.70	2,588	29	2.84	
			30	8.70	2,588	30	2.39	
		44,460			66,209			

Table showing the daily discharge and height of the Connecticut River, &c.—Continued.

Date.	Height, feet.	Millions of cubic feet.	Date.	Height, feet.	Millions of cubic feet.	Date.	Height, feet.	Millions of cubic feet.
1871.			1871.			1871.		
July 1	2.55	650	Sept. 1	6.48	1,740	Nov. 1	4.82	1,100
2	2.12	574	2	6.25	1,630	2	4.44	1,058
3	1.67	535	3	5.15	1,262	3	3.88	917
4	1.70	538	4	4.37	1,036	4	3.33	782
5	1.52	519	5	3.67	865	5	2.75	679
6	1.54	521	6	3.05	740	6	2.84	703
7	1.54	521	7	2.45	628	7	2.84	703
8	1.02	477	8	2.00	561	8	2.89	709
9	1.21	493	9	1.84	551	9	2.93	713
10	1.21	493	10	1.66	534	10	3.16	756
11	1.46	513	11	1.45	512	11	2.76	680
12	1.85	552	12	1.46	513	12	2.90	710
13	1.70	538	13	1.58	525	13	2.79	684
14	2.14	586	14	1.49	516	14	3.05	740
15	1.69	537	15	1.52	519	15	4.11	970
16	1.19	491	16	1.89	549	16	9.82	3,080
17	1.79	547	17	2.04	565	17	11.35	3,775
18	1.51	518	18	1.37	509	18	9.68	3,020
19	1.59	526	19	2.05	566	19	8.17	2,375
20	1.69	537	20	2.09	570	20	6.56	1,735
21	1.58	525	21	1.82	549	21	5.54	1,380
22	1.41	508	22	1.43	510	22	5.52	1,375
23	1.62	530	23	1.49	516	23	5.50	1,370
24	1.62	530	24	1.35	507	24	5.36	1,330
25	1.61	528	25	1.55	522	25	5.87	1,495
26	1.61	528	26	1.94	555	26	6.33	1,665
27	1.53	520	27	2.11	573	27	5.72	1,440
28	1.86	548	28	2.11	573	28	5.42	1,345
29	1.88	550	29	1.82	549	29	4.74	1,135
30	1.80	547	30	1.73	541	30	3.78	895
31	1.74	542						
		16,522			20,286			39,379
Aug. 1	2.53	648	Oct. 1	1.43	510	Dec. 1	3.61	856
2	2.53	648	2	1.55	522	2	4.17	977
3	2.46	629	3	1.84	553	3	4.47	1,060
4	2.54	650	4	1.60	527	4	4.71	1,126
5	2.64	660	5	1.52	519	5	4.67	1,121
6	2.56	652	6	1.69	537	6	4.37	1,040
7	2.49	632	7	1.91	554	7	4.67	1,121
8	2.33	613	8	2.04	565	8	4.67	1,121
9	2.28	608	9	1.93	554	9	3.36	792
10	2.64	660	10	1.93	554	10	3.33	786
11	2.37	617	11	1.94	555	11	3.33	786
12	2.38	618	12	3.36	791	12	3.45	808
13	2.32	612	13	4.68	1,124	13	3.53	834
14	2.26	604	14	4.68	1,124	14	3.36	792
15	2.12	574	15	5.80	1,475	15	2.94	715
16	1.82	549	16	5.60	1,403	16	3.00	726
17	1.36	508	17	5.40	1,335	17	2.92	712
18	1.28	500	18	4.61	1,102	18	2.86	690
19	1.26	498	19	3.79	881	19	2.89	693
20	1.18	490	20	3.07	743	20	2.95	717
21	1.11	485	21	2.54	650	21	2.61	657
22	1.08	482	22	2.46	629	22	2.95	716
23	1.11	485	23	2.54	650	23	2.75	678
24	1.56	523	24	2.56	652	24	3.36	792
25	1.50	517	25	2.60	656	25	5.36	1,330
26	1.54	521	26	2.64	660	26	7.95	2,280
27	1.76	543	27	2.68	665	27	8.32	2,430
28	2.00	561	28	3.50	814	28	8.36	2,450
29	2.50	633	29	3.92	923	29	7.70	2,180
30	3.82	884	30	3.90	920	30	6.00	1,525
31	6.03	1,555	31	4.55	1,070	31	6.47	1,700
		19,159			24,217			34,211

Table showing the daily discharge and height of the Connecticut River at Hartford January 1 to December 31, 1872.

Date.	Height, feet.	Millions of cubic feet.	Date.	Height, feet.	Millions of cubic feet.	Date.	Height, feet.	Mill cubi
1872.			1872.			1872.		
Jan. 1	5.44	1,350	Mar. 1	2.45	628	May 1	12.06	
2	5.21	1,279	2	2.43	625	2	11.18	
3	5.58	1,390	3	2.76	680	3	11.96	
4	6.07	1,570	4	3.03	729	4	13.11	
5	6.67	1,780	5	2.32	612	5	13.33	
6	6.42	1,685	6	1.61	525	6	13.68	
7	5.39	1,335	7	1.81	548	7	13.67	
8	4.39	1,042	8	2.11	573	8	12.83	
9	4.04	960	9	1.86	547	9	11.64	
10	4.18	980	10	2.76	663	10	10.19	
11	4.11	970	11	4.50	1,065	11	9.60	
12	4.21	985	12	4.89	1,175	12	9.29	
13	4.03	950	13	4.56	1,071	13	9.00	
14	3.78	880	14	4.11	970	14	8.46	
15	3.35	790	15	3.82	884	15	7.49	
16	3.42	800	16	2.31	611	16	6.69	
17	3.47	810	17	2.20	598	17	5.77	
18	3.20	760	18	2.78	682	18	5.71	
19	2.98	720	19	2.58	654	19	5.87	
20	3.47	820	20	2.28	608	20	6.75	
21	3.67	865	21	2.47	630	21	6.20	
22	3.75	877	22	1.72	540	22	5.88	
23	3.81	883	23	2.06	568	23	5.58	
24	2.86	690	24	2.06	568	24	6.35	
25	2.47	630	25	2.08	570	25	6.14	
26	2.30	610	26	2.39	619	26	6.83	
27	2.28	608	27	2.47	630	27	7.60	
28	2.17	590	28	2.97	719	28	6.75	
29	2.03	564	29	3.57	850	29	6.11	
30	1.94	555	30	4.67	1,120	30	6.12	
31	1.99	560	31	4.89	1,175	31	6.60	
		29,288			22,437			
Feb. 1	1.92	552	Apr. 1	5.67	1,425	June 1	6.83	
2	2.11	573	2	4.08	964	2	6.87	
3	2.45	628	3	3.69	867	3	6.83	
4	2.86	690	4	3.61	855	4	7.03	
5	3.05	740	5	4.14	973	5	7.29	
6	3.11	750	6	4.53	1,075	6	7.57	
7	2.92	712	7	4.92	1,185	7	7.62	
8	2.83	702	8	7.06	1,925	8	7.65	
9	2.64	660	9	9.75	3,050	9	7.79	
10	2.15	587	10	12.72	4,410	10	7.99	
11	2.17	581	11	18.30	7,510	11	8.68	
12	2.36	616	12	19.65	8,475	12	13.36	
13	3.17	752	13	18.70	7,750	13	14.81	
14	3.90	920	14	18.40	7,580	14	14.26	
15	3.43	801	15	19.03	8,010	15	12.24	
16	3.06	741	16	17.21	6,820	16	11.45	
17	2.76	680	17	15.01	5,550	17	8.58	
18	2.36	616	18	12.87	4,480	18	7.14	
19	2.19	583	19	11.56	3,870	19	5.78	
20	2.22	600	20	11.58	3,872	20	5.21	
21	2.20	598	21	11.92	4,030	21	5.04	
22	2.25	603	22	13.20	4,640	22	4.68	
23	2.39	619	23	15.31	5,720	23	3.46	
24	2.28	608	24	15.89	6,040	24	3.46	
25	2.25	603	25	15.03	5,552	25	3.90	
26	2.19	583	26	14.15	5,100	26	4.25	
27	2.11	573	27	13.64	4,850	27	4.17	
28	2.08	570	28	14.15	5,100	28	4.49	
29	2.28	608	29	13.68	4,880	29	4.58	
			30	12.70	4,408	30	4.49	
		18,849			130,966			

Table showing the daily discharge and height of the Connecticut River, &c.—Continued.

Date.	Height, feet.	Millions of cubic feet.	Date.	Height, feet.	Millions of cubic feet.	Date.	Height, feet.	Millions of cubic feet.
1872.			1872.			1872.		
July 1	3.92	923	Sept. 1	9.22	2,820	Nov. 1	5.92	1,510
2	3.35	785	2	9.35	2,875	2	5.58	1,390
3	3.10	740	3	9.11	2,775	3	5.58	1,390
4	3.26	775	4	8.57	2,540	4	5.44	1,350
5	3.40	800	5	7.99	2,300	5	5.74	1,460
6	3.76	880	6	6.97	1,885	6	5.65	1,425
7	3.51	830	7	6.76	1,825	7	6.61	1,760
8	3.08	738	8	6.61	1,760	8	8.29	2,420
9	2.97	720	9	4.96	1,200	9	8.67	2,575
10	3.17	750	10	4.73	1,140	10	7.70	2,182
11	3.53	832	11	4.67	1,120	11	8.08	2,335
12	3.97	935	12	4.95	1,198	12	7.36	2,040
13	3.78	882	13	5.96	1,525	13	7.39	2,050
14	3.54	833	14	6.05	1,560	14	10.81	3,530
15	3.39	790	15	6.18	1,600	15	12.08	4,110
16	3.53	832	16	6.32	1,660	16	12.79	4,440
17	3.51	830	17	6.97	1,900	17	12.56	4,340
18	3.37	787	18	7.36	2,040	18	10.03	3,175
19	3.45	816	19	6.96	1,895	19	8.87	2,670
20	3.32	780	20	7.18	1,975	20	7.78	2,215
21	3.44	810	21	6.60	1,755	21	6.97	1,890
22	3.39	798	22	5.90	1,500	22	6.69	1,780
23	3.50	828	23	5.43	1,350	23	6.25	1,625
24	3.51	830	24	4.97	1,210	24	5.86	1,490
25	3.62	850	25	4.80	1,160	25	5.67	1,425
26	4.92	1,190	26	4.93	1,185	26	5.36	1,325
27	4.89	1,180	27	5.50	1,370	27	5.42	1,340
28	4.51	1,070	28	8.40	2,470	28	5.39	1,335
29	4.33	1,025	29	7.20	1,975	29	5.06	1,240
30	4.36	1,031	30	6.78	1,820	30	4.57	1,080
31	4.39	1,038						
		26,918			53,388			62,897
Aug. 1	5.22	1,280	Oct. 1	5.87	1,490	Dec. 1	4.42	1,050
2	3.79	884	2	5.43	1,375	2	4.61	1,100
3	3.57	840	3	4.86	1,175	3	5.06	1,240
4	4.13	971	4	4.53	1,075	4	4.89	1,180
5	5.07	1,236	5	4.55	1,085	5	4.59	1,090
6	5.67	1,425	6	4.08	960	6	5.03	1,230
7	6.24	1,625	7	4.01	936	7	5.20	1,280
8	6.43	1,725	8	4.03	950	8	5.36	1,330
9	6.06	1,560	9	3.85	900	9	5.39	1,340
10	5.48	1,370	10	4.25	1,000	10	3.75	880
11	3.93	923	11	4.58	1,090	11	4.00	933
12	3.72	870	12	4.75	1,140	12	4.78	1,150
13	4.03	950	13	5.01	1,220	13	5.92	1,500
14	4.29	1,015	14	5.26	1,280	14	7.00	1,920
15	4.82	1,160	15	5.51	1,375	15	6.94	1,830
16	5.86	1,485	16	5.84	1,440	16	7.06	1,925
17	8.36	2,440	17	5.99	1,540	17	7.39	2,050
18	11.58	3,880	18	5.76	1,450	18	7.30	2,020
19	12.14	4,150	19	5.73	1,440	19	7.22	1,985
20	11.82	3,995	20	5.03	1,225	20	6.00	1,540
21	11.07	3,650	21	5.86	1,490	21	6.00	1,540
22	10.03	3,175	22	6.42	1,680	22	6.11	1,575
23	9.48	2,940	23	5.88	1,500	23	6.00	1,540
24	8.97	2,710	24	6.14	1,580	24	6.00	1,540
25	8.67	2,580	25	5.94	1,522	25	6.00	1,540
26	8.33	2,440	26	5.22	1,280	26	6.00	1,540
27	7.27	2,000	27	5.67	1,430	27	6.00	1,540
28	6.03	1,540	28	5.85	1,480	28	6.00	1,540
29	5.17	1,270	29	6.64	1,775	29	6.00	1,540
30	5.76	1,460	30	7.64	2,170	30	6.00	1,540
31	8.39	2,460	31	6.92	1,870	31	6.00	1,540
		59,996			41,923			45,548

Table showing the daily discharge and height of the Connecticut River at Hartford, from January 1 to December 31, 1873.

Date.	Height, feet.	Millions of cubic feet.	Date.	Height, feet.	Millions of cubic feet.	Date.	Height, feet.	Millions of cubic feet.
1873.			1873.			1873.		
Jan. 1	6.00	1,540	Mar. 1	4.41	1,048	May 1	15.14	5,625
2	6.00	1,540	2	4.44	1,054	2	15.33	5,725
3	6.00	1,540	3	5.11	1,240	3	16.08	6,140
4	6.00	1,540	4	4.83	1,168	4	17.61	7,000
5	6.05	1,570	5	4.45	1,056	5	17.02	6,700
6	6.14	1,585	6	4.42	1,050	6	15.96	6,075
7	6.28	1,641	7	4.36	1,038	7	15.03	5,550
8	6.71	1,800	8	4.55	1,085	8	13.89	4,900
9	7.19	1,975	9	4.42	1,050	9	13.30	4,600
10	7.00	1,910	10	4.22	987	10	14.30	5,100
11	6.19	1,600	11	4.53	1,075	11	14.97	5,500
12	5.61	1,405	12	4.94	1,196	12	15.20	5,600
13	5.12	1,252	13	5.53	1,375	13	15.62	5,900
14	5.07	1,238	14	6.33	1,660	14	15.86	6,075
15	5.00	1,218	15	6.34	1,662	15	15.64	5,910
16	5.20	1,278	16	5.92	1,510	16	14.76	5,420
17	5.42	1,345	17	5.69	1,435	17	13.75	4,920
18	6.61	1,760	18	5.97	1,540	18	12.50	4,310
19	7.61	2,140	19	6.14	1,590	19	11.07	3,650
20	12.44	4,275	20	6.39	1,675	20	9.95	3,140
21	13.42	4,740	21	6.72	1,800	21	9.14	2,780
22	12.55	4,330	22	6.25	1,625	22	8.85	2,670
23	10.83	3,540	23	5.82	1,430	23	9.60	2,900
24	9.97	3,150	24	5.72	1,445	24	9.83	3,000
25	9.47	2,930	25	5.35	1,320	25	9.61	2,900
26	7.45	2,075	26	5.22	1,280	26	9.42	2,820
27	7.17	1,973	27	4.98	1,210	27	9.33	2,870
28	7.14	1,970	28	4.75	1,140	28	9.07	2,730
29	6.75	1,820	29	5.24	1,285	29	9.03	2,700
30	6.58	1,750	30	8.32	2,435	30	8.52	2,510
31	6.97	1,900	31	9.64	3,010	31	7.72	2,180
		64,430			43,316			138,720
Feb. 1	7.33	2,030	Apr. 1	9.74	3,045	June 1	6.90	1,870
2	7.00	1,910	2	11.27	3,740	2	6.08	1,560
3	7.42	2,070	3	12.97	4,540	3	5.46	1,360
4	8.00	2,310	4	13.29	4,680	4	4.86	1,177
5	7.53	2,120	5	13.24	4,660	5	4.64	1,110
6	6.92	1,880	6	13.22	4,650	6	4 44	1,060
7	6.31	1,650	7	13.29	4,680	7	4.21	1,000
8	5.97	1,530	8	13.64	4,870	8	4.25	1,010
9	5.30	1,300	9	15.05	5,575	9	4.40	1,045
10	5.45	1,380	10	17.12	6,770	10	4.50	1,080
11	5.86	1,480	11	19.10	8,070	11	4.14	975
12	6.58	1,750	12	20.30	8,925	12	3.80	880
13	5.42	1,346	13	20.85	9,375	13	3.56	810
14	5.40	1,340	14	19.80	8,570	14	3.86	900
15	5.26	1,290	15	18.78	7,740	15	3.97	925
16	5.05	1,233	16	17.94	7,255	16	3.50	835
17	5.25	1,284	17	17.51	7,000	17	3.01	725
18	6.53	1,725	18	17.68	7,120	18	2.64	640
19	7.50	2,100	19	17.28	6,870	19	2.62	635
20	7.35	2,040	20	16.56	6,425	20	2.58	625
21	6.83	1,840	21	16.63	6,465	21	2.46	600
22	6.25	1,625	22	17.13	6,775	22	2.43	590
23	6.03	1,550	23	16.86	6,560	23	2.36	575
24	5.86	1,490	24	16.15	6,175	24	2.32	565
25	6.59	1,640	25	15.62	5,890	25	2.32	565
26	4.95	1,040	26	15.05	5,575	26	2.11	515
27	4.42	1,050	27	14.10	5,075	27	2.06	500
28	4.67	1,120	28	13.36	4,720	28	2.16	525
			29	13.54	4,825	29	2.57	625
			30	14.23	5,160	30	2.32	565
		45,123			181,780			26,400

Table showing the daily discharge and height of the Connecticut River, &c.—Continued.

Date.	Height, feet.	Millions of cubic feet.	Date.	Height, feet.	Millions of cubic feet.	Date.	Height, feet.	Millions of cubic feet.
1873.			1873.			1873.		
y 1	2.32	612	Sept. 1	1.24	496	Nov. 1	8.19	2,384
2	1.72	540	2	1.09	483	2	7.42	2,060
3	1.67	532	3	0.99	474	3	6.65	1,775
4	1.77	544	4	1.58	525	4	6.07	1,565
5	1.68	535	5	1.87	549	5	5.68	1,430
6	1.82	550	6	1.43	510	6	5.24	1,290
7	2.39	619	7	1.81	548	7	4.97	1,210
8	2.85	689	8	1.72	540	8	5.31	1,310
9	2.69	665	9	1.76	544	9	6.18	1,590
10	2.57	653	10	1.92	552	10	6.45	1,700
11	2.32	612	11	2.08	570	11	6.50	1,720
12	2.20	598	12	1.90	550	12	6.36	1,670
13	2.13	575	13	1.92	550	13	5.69	1,435
14	2.18	596	14	1.79	547	14	5.29	1,300
15	2.21	599	15	0.88	465	15	5.01	1,225
16	2.26	604	16	1.32	504	16	4.98	1,210
17	2.29	608	17	1.31	503	17	4.75	1,140
18	2.30	609	18	1.54	521	18	5.21	1,279
19	2.26	604	19	1.75	543	19	4.14	975
20	2.56	652	20	1.12	486	20	4.40	1,044
21	3.49	820	21	1.48	515	21	3.97	928
22	3.53	846	22	2.21	585	22	3.93	924
23	2.75	679	23	2.81	685	23	3.69	868
24	2.36	616	24	2.64	660	24	4.12	971
25	2.32	612	25	3.59	352	25	4.36	1,031
26	2.36	616	26	4.37	1,039	26	4.32	1,033
27	1.79	547	27	3.80	882	27	3.91	921
28	1.48	515	28	3.18	757	28	5.11	1,250
29	2.11	573	29	2.76	680	29	5.41	1,345
30	2.24	604	30	2.25	603	30	5.37	1,332
31	1.98	558						
		18,962			17,718			39,915
	1.95	555	Oct. 1	2.30	610	Dec. 1	4.81	1,160
	1.78	545	2	2.38	618	2	5.16	1,270
	1.82	549	3	2.26	604	3	5.41	1,385
	2.21	599	4	2.55	651	4	5.88	1,490
	1.76	544	5	2.85	705	5	10.08	3,208
	2.20	598	6	2.64	689	6	12.21	4,170
	2.20	598	7	3.93	924	7	12.64	4,375
	2.09	571	8	8.50	2,510	8	10.01	3,170
	2.04	566	9	10.53	3,400	9	8.01	2,310
	1.88	550	10	11.11	3,670	10	7.87	2,240
	2.03	564	11	9.81	3,080	11	7.91	2,260
	2.08	570	12	8.29	2,425	12	7.45	2,075
	2.09	571	13	6.64	1,775	13	7.95	2,275
	2.28	608	14	5.32	1,310	14	10.38	3,340
	1.76	544	15	4.33	1,075	15	10.30	3,300
	1.51	518	16	3.76	879	16	8.65	2,575
	1.08	482	17	3.29	772	17	7.34	2,040
	1.46	513	18	3.28	770	18	6.80	1,825
	1.74	542	19	3.39	795	19	6.12	1,575
	1.72	540	20	4.14	975	20	6.29	1,640
	1.80	547	21	9.76	3,052	21	4.88	1,173
	2.36	616	22	15.28	5,680	22	5.01	1,225
	2.70	666	23	15.17	5,625	23	5.38	1,333
	1.90	550	24	13.09	4,580	24	5.62	1,410
	2.01	562	25	10.33	3,320	25	7.04	1,917
	2.19	583	26	8.03	2,320	26	6.87	1,850
	1.75	543	27	7.01	1,920	27	6.48	1,720
	1.69	537	28	8.50	2,510	28	7.49	2,090
	1.58	525	29	11.08	3,660	29	6.98	1,900
	1.43	510	30	10.09	3,210	30	7.80	2,225
	1.32	504	31	8.93	2,695	31	7.77	2,200
		17,270			66,780			66,726

Table showing the daily discharge and height of the Connecticut River at Hartford, fr
January 1 *to December* 31, 1874.

Date.	Height, feet.	Millions of cubic feet.	Date.	Height, feet.	Millions of cubic feet.	Date.	Height, feet.	Millions cubic fe
1874.			1874.			1874.		
Jan. 1	7.89	2,254	Mar. 1	10.33	3,320	May 1	9.62	
2	8.06	2,335	2	8.79	2,626	2	9.21	
3	8.13	2,360	3	6.49	1,712	3	9.03	
4	8.06	2,335	4	6.58	1,752	4	9.00	
5	10.96	3,597	5	10.39	3,345	5	9.95	
6	11.49	3,833	6	13.34	4,710	6	11.68	
7	12.66	4,383	7	13.28	4,675	7	12.87	
8	17.93	7,250	8	11.25	3,730	8	12.40	
9	23.51	11,520	9	9.86	3,092	9	11.60	
10	23.46	11,530	10	8.19	2,384	10	10.84	
11	20.75	9,280	11	6.73	1,814	11	13.40	
12	17.76	7,170	12	5.90	1,502	12	14.72	
13	14.37	5,220	13	5.16	1,270	13	13.76	
14	11.05	3,640	14	6.59	1,756	14	12.97	
15	8.98	2,705	15	7.53	2,120	15	12.79	
16	7.66	2,170	16	6.66	1,778	16	13.21	
17	7.45	2,075	17	5.73	1,448	17	14.43	
18	9.42	2,920	18	4.91	1,187	18	14.65	
19	10.20	3,255	19	6.76	1,824	19	14.40	
20	10.56	3,415	20	8.27	2,419	20	14.13	
21	10.45	3,370	21	10.41	3,350	21	13.90	
22	10.72	3,485	22	10.42	3,355	22	14.83	
23	11.48	3,829	23	9.62	2,994	23	16.21	
24	11.83	3,990	24	8.07	2,338	24	15.62	
25	11.28	3,745	25	7.48	2,095	25	14.28	
26	10.01	3,175	26	6.67	1,781	26	14.07	
27	11.83	3,990	27	6.22	1,616	27	14.99	
28	12.52	4,320	28	6.09	1,570	28	14.35	
29	12.53	4,325	29	5.77	1,460	29	12.93	
30	12.42	4,265	30	5.65	1,420	30	11.40	
31	11.29	3,750	31	5.20	1,278	31	10.22	
		135,491			71,721			13
Feb. 1	9.01	2,717	Apr. 1	5.04	1,228	June 1	9.54	
2	8.80	2,635	2	4.79	1,157	2	9.64	
3	9.25	2,835	3	4.55	1,085	3	9.56	
4	9.17	2,805	4	4.19	982	4	9.05	
5	9.22	2,820	5	4.07	960	5	8.54	
6	9.20	2,810	6	4.01	946	6	7.99	
7	9.28	2,845	7	4.02	948	7	7.61	
8	9.13	2,785	8	4.16	975	8	8.50	
9	8.94	2,700	9	4.45	1,056	9	11.63	
10	8.89	2.685	10	5.56	1,384	10	11.21	
11	8.76	2,615	11	5.97	1,530	11	9.30	
12	8.56	2,535	12	5.27	1,295	12	7.72	
13	8.49	2,508	13	4.98	1,210	13	7.35	
14	10.19	3,250	14	4.75	1,145	14	6.71	
15	13.38	4,730	15	4.98	1,210	15	6.56	
16	15.44	5,790	16	6.49	1,712	16	6.51	
17	15.01	5,538	17	9.56	2,964	17	6.29	
18	13.12	4,598	18	10.05	3,190	18	7.25	
19	11.44	3,815	19	9.08	2,755	19	8.83	
20	10.10	3,214	20	8.63	2,567	20	10.64	
21	9.23	2,824	21	11.16	3,688	21	11.22	
22	8.94	2,700	22	12.23	3,720	22	10.67	
23	10.24	3,275	23	10.37	3,335	23	9.68	
24	12.17	4,150	24	9.97	3,150	24	8.45	
25	12.84	4,465	25	9.60	2,985	25	7.23	
26	13.08	4,580	26	9.53	2,950	26	6.99	
27	12.97	4,540	27	8.99	2,708	27	7.30	
28	11.64	3,910	28	9.46	2,928	28	6.86	
			29	9.81	3,080	29	5.94	
			30	10.03	3,185	30	5.31	
		96,674			62,031			

able showing the daily discharge and height of the Connecticut River, &c.—Continued.

Date.	Height, feet.	Millions of cubic feet.	Date.	Height, feet.	Millions of cubic feet.	Date.	Height, feet.	Millions of cubic feet.
1874.			1874.			1874.		
ly 1	4.77	1,151	Sept. 1	2.51	634	Nov. 1	1.56	520
2	4.58	1,090	2	2.22	600	2	1.32	500
3	4.64	1,110	3	2.00	561	3	1.47	515
4	4.73	1,140	4	1.43	510	4	1.50	520
5	6.28	1,636	5	1.45	512	5	1.87	550
6	9.16	2,800	6	1.39	511	6	1.68	530
7	8.97	2,712	7	1.49	516	7	0.89	475
8	7.65	2,155	8	1.77	545	8	1.90	560
9	6.61	1,760	9	1.89	551	9	1.66	530
10	5.87	1,487	10	1.95	556	10	1.50	520
11	5.44	1,353	11	1.89	551	11	1.56	525
12	7.15	1,974	12	2.27	607	12	0.75	470
13	13.58	4,840	13	2.30	610	13	0.87	475
14	14.37	5,220	14	2.33	613	14	0.96	480
15	12.45	4,280	15	2.05	566	15	0.96	480
16	10.07	3,200	16	2.09	571	16	0.97	480
17	8.12	2,356	17	1.94	555	17	1.22	495
18	6.66	1,778	18	2.31	611	18	1.54	520
19	5.42	1,349	19	1.86	553	19	1,24	500
20	4.70	1,134	20	1.76	544	20	1.75	540
21	4.80	1,160	21	1.81	550	21	1.83	550
22	5.38	1,334	22	2.05	575	22	1.65	530
23	4.90	1,184	23	2.01	570	23	2.29	600
24	4.37	1,034	24	2.06	580	24	2.02	570
25	3.88	903	25	2.11	580	25	1.74	540
26	3.46	814	26	2.27	600	26	2.00	570
27	3.41	800	27	2.42	620	27	2.07	575
28	3.29	773	28	2.89	700	28	1.45	515
29	3.30	777	29	3.08	740	29	2.13	680
30	3.32	782	30	2.34	620	30	2.56	650
31	3.95	932						
		55,018			17,412			15,865
Aug. 1	4.52	1,074	Oct. 1	2.19	590	Dec. 1	2.32	615
2	4.72	1,135	2	2.50	640	2	2.16	590
3	4.55	1,084	3	2.42	620	3	2.74	675
4	4.30	1,028	4	2.43	620	4	2.57	650
5	3.90	920	5	2.49	640	5	2.78	680
6	3.64	854	6	2.63	660	6	2.70	670
7	3.35	783	7	2.65	660	7	2.99	725
8	3.34	781	8	2.45	630	8	3.10	740
9	4.60	1,096	9	2.64	660	9	2.89	700
10	5.30	1,302	10	3.34	780	10	2.12	580
11	5.00	1,220	11	3.69	870	11	2.43	625
12	4.74	1,143	12	3.56	840	12	1.69	530
13	4.40	1,044	13	3.25	770	13	1.18	490
14	3.94	928	14	3.01	730	14	1.32	500
15	3.64	854	15	2.72	670	15	0.44	450
16	4.28	1,020	16	2.32	620	16	1.73	540
17	4.95	1,198	17	2.09	580	17	1.75	540
18	4.59	1,093	18	2.15	580	18	1.30	500
19	3.79	879	19	1.78	550	19	1.50	520
20	3.48	822	20	1.63	530	20	1.58	525
21	2.75	679	21	1.63	530	21	2.52	645
22	2.84	689	22	2.56	600	22	2.46	625
23	3.19	758	23	1.91	560	23	2.10	580
24	3.04	733	24	1.97	565	24	2.31	610
25	3.01	727	25	1.75	540	25	0.92	475
26	3.04	733	26	1.71	535	26	1.00	480
27	3.07	740	27	1.76	540	27	1.10	490
28	3.14	751	28	1.72	535	28	1.71	540
29	3.17	756	29	1.82	550	29	2.10	580
30	3.08	742	30	1.96	565	30	2.11	580
31	3.01	727	31	1.81	550	31	1.46	515
		28,293			19,310			17,965

Table for the months and years.

	1871.	1872.	1873.	1874.
	Cubic feet.	*Cubic feet.*	*Cubic feet.*	*Cubic feet.*
January	.....	29, 288, 000, 000	64, 430, 000, 000	135, 491, 000, [illegible]
February	44, 460, 000, 000	18, 849, 000, 000	45, 123, 000, 000	96, 674, 000, [illegible]
March	134, 328, 000, 000	22, 437, 000, 000	43, 316, 000, 000	71, 721, 000, [illegible]
April	66, 209, 000, 000	130, 966, 000, 000	181, 780, 000, 000	62, 031, 000, [illegible]
May	80, 886, 000, 000	82, 164, 000, 000	138, 720, 000, 000	139, 213, 000, [illegible]
June	23, 686, 000, 000	63, 696, 000, 000	26, 400, 000, 000	74, 110, 000, [illegible]
July	16, 522, 000, 000	26, 918, 000, 000	18, 982, 000, 000	55, 018, 000, [illegible]
August	19, 159, 000, 000	59, 996, 000, 000	17, 270, 000, 000	28, 293, 000, [illegible]
September	20, 286, 000, 000	53, 388, 000, 000	17, 718, 000, 000	17, 412, 000, [illegible]
October	24, 217, 000, 000	41, 923, 000, 000	66, 780, 000, 000	19, 310, 000, [illegible]
November	39, 379, 000, 000	62, 897, 000, 000	39, 915, 000, 000	15, 865, 000, [illegible]
December	34, 211, 000, 000	45, 548, 000, 000	66, 726, 000, 000	17, 965, 000, [illegible]
January, 1872	29, 288, 000, 000	.....	.....	.....
Totals	532, 631, 000, 000	638, 070, 000, 000	727, 160, 000, 000	733, 103, 000, [illegible]

Table showing the number of days in 1871 *that the average for the day at Hartford was abo a given height.*

Height.	No. of days.	Height.	No. of days.	Height.	No. of days.	Height.	No. day
FEBRUARY.		2 feet and over..	30	3 feet and over...	17	NOVEMBER.	
		3 feet and over..	30	4 feet and over...	3		
1 foot and over...	28	4 feet and over..	30	5 feet and over...	2	1 foot and over..	
2 feet and over...	28	5 feet and over..	30			2 feet and over..	
3 feet and over...	17	6 feet and over..	30			3 feet and over..	
4 feet and over...	14	7 feet and over..	26	JULY.		4 feet and over..	
5 feet and over...	12	8 feet and over..	12			5 feet and over..	
6 feet and over...	10	9 feet and over..	3	1 foot and over...	31	6 feet and over..	
7 feet and over...	9	10 feet and over..	2	2 feet and over...	3	7 feet and over..	
8 feet and over...	7					8 feet add over..	
9 feet and over...	6					9 feet and over..	
10 feet and over...	5	MAY.		AUGUST.		10 feet and over..	
11 feet and over...	4					11 feet and over..	
12 feet and over...	2	1 foot and over..	31	1 foot and over...	31		
		2 feet and over..	31	2 feet and over...	19		
MARCH.		3 feet and over..	31	3 feet and over...	2	DECEMBER.	
		4 feet and over..	31	4 feet and over...	1		
1 foot and over...	31	5 feet and over..	20	5 feet and over...	1		
2 feet and over...	31	6 feet and over..	17	6 feet and over...	1	1 foot and over..	
3 feet and over...	31	7 feet and over..	15			2 feet and over..	
4 feet and over...	31	8 feet and over..	11	SEPTEMBER.		3 feet and over..	
5 feet and over...	31	9 feet and over..	9			4 feet and over	
6 feet and over...	31	10 feet and over..	8			5 feet and over..	
7 feet and over...	29	11 feet and over..	7	1 foot and over...	30	6 feet add over..	
8 feet and over...	27	12 feet and over..	6	2 feet and over...	13	7 feet and over..	
9 feet and over...	27	13 feet and over..	5	3 feet and over ..	6	8 feet and over..	
10 feet and over ..	27	14 feet and over..	5	4 feet and over...	4		
11 feet and over...	27	15 feet and over..	4	5 feet and over...	3		
12 feet and over...	24	16 feet and over..	4	6 feet and over...	2	JANUARY, 1872.	
13 feet and over...	16	17 feet and over..	4				
14 feet and over...	6	18 feet and over..	3	OCTOBER.			
15 feet and over...	6					1 foot and over..	
16 feet and over...	2	JUNE.		1 foot and over...	31	2 feet and over..	
				2 feet and over...	21	3 feet and over..	
APRIL.				3 feet and over ..	13	4 feet and over..	
		1 foot and over..	30	4 feet and over...	7	5 feet and over..	
1 foot and over...	30	2 feet and over..	29	5 feet and over...	3	6 feet and over..	

Total for the year from February 1, 1871, *to January* 31, 1872.

Total for twelve months.		Total for twelve months.		Total for twelve months.		Total for twelve mont	
Height.	No. of days.	Height.	No. of days.	Height.	No. of days.	Height.	No. day
1 foot and over....	365	6 feet and over..	106	11 feet and over..	39	15 feet and over..	
2 feet and over....	295	7 feet and over..	87	12 feet and over..	32	16 feet and over..	
3 feet and over....	214	8 feet and over..	63	13 feet and over..	21	17 feet and over..	
4 feet and over....	165	9 feet and over..	48	14 feet and over..	11	18 feet and over..	
5 feet and over....	129	10 feet and over..	43				

le showing the number of days in 1872 that the average for the day at Hartford was above a given height.

Height.	No. of days.	Height.	No. of days.	Height.	No. of days.	Height.	No. of days.
JANUARY.		13 feet and over..	15	11 feet and over..	5	8 feet and over..	5
		14 feet and over..	12	12 feet and over..	4	9 feet and over..	3
foot and over ..	31	15 feet and over..	10	13 feet and over..	3		
feet and over ..	29	16 feet and over..	6	14 feet and over..	2	OCTOBER.	
feet and over ..	22	17 feet and over..	6				
feet and over ..	13	18 feet and over..	5	JULY.		1 foot and over..	31
feet and over ..	7	19 feet and over..	2			2 feet and over..	31
feet and over ..	3			1 foot and over..	31	3 feet and over..	31
		MAY.		2 feet and over..	31	4 feet and over..	30
FEBRUARY.				3 feet and over..	30	5 feet and over..	21
		1 foot and over..	31	4 feet and over..	6	6 feet and over..	5
foot and over ..	29	2 feet and over..	31			7 feet and over..	1
feet and over ..	28	3 feet and over..	31	AUGUST.			
feet and over ..	6	4 feet and over..	31			NOVEMBER.	
		5 feet and over..	31	1 foot and over..	31		
MARCH.		6 feet and over..	26	2 feet and over..	31	1 foot and over..	30
		7 feet and over..	16	3 feet and over..	31	2 feet and over..	30
foot and over ..	31	8 feet and over..	14	4 feet and over..	27	3 feet and over..	30
feet and over ..	27	9 feet and over..	13	5 feet and over..	23	4 feet and over..	30
feet and over ..	9	10 feet and over..	10	6 feet and over..	16	5 feet and over..	29
feet and over ..	6	11 feet and over..	9	7 feet and over..	12	6 feet and over..	17
		12 feet and over..	6	8 feet and over..	11	7 feet and over..	13
APRIL.		13 feet and over..	4	9 feet and over..	6	8 feet and over..	9
				10 feet and over..	5	9 feet and over..	5
feet and over ..	30	JUNE.		11 feet and over..	4	10 feet and over..	5
feet and over ..	30			12 feet and over..	1	11 feet and over..	3
feet and over ..	30	1 foot and over..	30			12 feet and over..	3
feet and over ..	28	2 feet and over..	30	SEPTEMBER.			
feet and over ..	24	3 feet and over..	30			DECEMBER.	
feet and over ..	23	4 feet and over..	27	1 foot and over..	30	1 foot and over..	31
feet and over ..	23	5 feet and over..	21	2 feet and over..	30	2 feet and over..	31
feet and over ..	22	6 feet and over..	18	3 feet and over..	30	3 feet and over..	31
feet and over ..	22	7 feet and over..	15	4 feet and over..	30	4 feet and over..	30
feet and over ..	21	8 feet and over..	7	5 feet and over..	23	5 feet and over..	24
feet and over ..	21	9 feet and over..	5	6 feet and over..	19	6 feet and over..	18
feet and over ..	18	10 feet and over..	5	7 feet and over..	9	7 feet and over..	5

Total for the year from January 1 to December 31, 1872.

Total for twelve months.		Total for twelve months.		Total for twelve months.		Total for twelve months.	
Height.	No. of days.	Height.	No. of days.	Height.	No. of days.	Height.	No. of days.
foot and over ..	366	6 feet and over..	145	11 feet and over..	42	16 feet and over..	6
feet and over ..	359	7 feet and over..	94	12 feet and over..	32	17 feet and over..	6
feet and over ..	311	8 feet and over..	68	13 feet and over..	22	18 feet and over..	5
feet and over ..	258	9 feet and over..	54	14 feet and over..	14	19 feet and over..	2
feet and over ..	203	10 feet and over..	46	15 feet and over..	10		

Table showing the number of days in 1873 *that the average for the day at Hartford was ab*
a given height.

Height.	No. of days.	Height.	No. of days.	Height.	No. of days.	Height.	No. day
JANUARY.		APRIL.		14 feet and over..	14	5 feet and over..	
				15 feet and over..	11	6 feet and over..	
1 foot and over ..	31	1 foot and over..	30	16 feet and over..	3	7 feet and over..	
2 feet and over ..	31	2 feet and over..	30	17 feet and over..	2	8 feet and over..	
3 feet and over ..	31	3 feet and over..	30			9 feet and over..	
4 feet and over ..	31	4 feet and over..	30	JUNE.		10 feet and over..	
5 feet and over ..	31	5 feet and over..	30			11 feet and over..	
6 feet and over ..	25	6 feet and over..	30	1 foot and over..	30	12 feet and over..	
7 feet and over ..	12	7 feet and over..	30	2 feet and over..	30	13 feet and over..	
8 feet and over ..	6	8 feet and over..	30	3 feet and over..	17	14 feet and over..	
9 feet and over ..	6	9 feet and over..	30	4 feet and over..	11	15 feet and over..	
10 feet and over ..	4	10 feet and over..	29	5 feet and over..	3		
11 feet and over ..	3	11 feet and over..	29	6 feet and over..	2	NOVEMBER.	
12 feet and over ..	3	12 feet and over..	28				
13 feet and over ..	1	13 feet and over..	27	JULY.		1 foot and over..	3
		14 feet and over..	20			2 feet and over..	3
FEBRUARY.		15 feet and over..	18	1 foot and over..	31	3 feet and over..	3
		16 feet and over..	15	2 feet and over..	23	4 feet and over..	2
1 foot and over ..	28	17 feet and over..	11	3 feet and over..	2	5 feet and over..	1
2 feet and over ..	28	18 feet and over..	5			6 feet and over..	
3 feet and over ..	28	19 feet and over..	4	AUGUST.		7 feet and over..	
4 feet and over ..	28	20 feet and over..	2			8 feet and over..	
5 feet and over ..	25			1 foot and over..	31		
6 feet and over ..	15	MAY.		2 feet and over..	13	DECEMBER.	
7 feet and over ..	7						
8 feet and over ..	1	1 foot and over..	31	SEPTEMBER.		1 foot and over..	3
		2 feet and over..	31			2 feet and over..	3
MARCH.		3 feet and over..	31	1 foot and over..	28	3 feet and over..	3
		4 feet and over..	31	2 feet and over..	10	4 feet and over..	3
1 foot and over ..	31	5 feet and over..	31	3 feet and over..	4	5 feet and over..	2
2 feet and over ..	31	6 feet and over..	31	4 feet and over..	1	6 feet and over..	2
3 feet and over ..	31	7 feet and over..	31			7 feet and over..	1
4 feet and over ..	31	8 feet and over..	30	OCTOBER.		8 feet and over..	
5 feet and over ..	18	9 feet and over..	28			9 feet and over..	
6 feet and over ..	8	10 feet and over..	19	1 foot and over..	31	10 feet and over..	
7 feet and over ..	2	11 feet and over..	19	2 feet and over..	31	11 feet and over..	
8 feet and over ..	2	12 feet and over..	18	3 feet and over .	25	12 feet and over..	
9 feet and over ..	1	13 feet and over..	17	4 feet and over..	20		

Total for the year from January 1 *to December* 31, 1873.

Total for twelve months.		Total for twelve months.		Total for twelve months.		Total for twelve mont	
Height.	No. of days.	Height.	No. of days.	Height.	No. of days.	Height.	No day
1 foot and over ..	363	6 feet and over..	159	11 feet and over..	59	16 feet and over..	
2 feet and over ..	319	7 feet and over..	117	12 feet and over..	55	17 feet and over..	
3 feet and over ..	260	8 feet and over..	93	13 feet and over..	49	18 feet and over..	
4 feet and over ..	240	9 feet and over..	81	14 feet and over..	37	19 feet and over..	
5 feet and over ..	203	10 feet and over..	67	15 feet and over..	31	20 feet and over..	

le showing the number of days in 1874 *that the average for the day at Hartford was above a given height.*

Height.	No. of days.	Height.	No. of days.	Height.	No. of days.	Height.	No. of days.
NUARY.		13 feet and over..	5	5 feet and over..	31	11 feet and over..	3
		14 feet and over..	3	6 feet and over..	31	12 feet and over..	3
and over ..	31	15 feet and over..	3	7 feet and over..	31	13 feet and over..	2
and over ..	31			8 feet and over..	31	14 feet and over..	1
and over ..	31	MARCH.		9 feet and over..	31		
and over ..	31			10 feet and over..	26	AUGUST.	
and over ..	31	1 foot and over..	31	11 feet and over..	24		
and over ..	31	2 feet and over..	31	12 feet and over..	21	1 foot and over..	31
and over ..	31	3 feet and over..	31	13 feet and over..	16	2 feet and over..	31
and over ..	28	4 feet and over..	31	14 feet and over..	12	3 feet and over..	29
and over ..	24	5 feet and over..	30	15 feet and over..	2	4 feet and over..	12
and over ..	23	6 feet and over..	24	16 feet and over..	1	5 feet and over..	2
and over ..	17	7 feet and over..	15				
and over ..	10	8 feet and over..	13	JUNE.		SEPTEMBER.	
and over ..	6	9 feet and over..	9				
and over ..	6	10 feet and over..	7	1 foot and over..	30	1 foot and over..	30
and over ..	5	11 feet and over..	3	2 feet and over..	30	2 feet and over..	30
and over ..	5	12 feet and over..	2	3 feet and over..	30	3 feet and over..	30
and over ..	5	13 feet and over..	2	4 feet and over..	30	4 feet and over..	30
and over ..	3			5 feet and over..	30	5 feet and over..	30
and over ..	3	APRIL.		6 feet and over..	28	6 feet and over..	11
and over ..	3			7 feet and over..	22	7 feet and over..	2
and over ..	2	1 foot and over..	30	8 feet and over..	15		
and over ..	2	2 feet and over..	30	9 feet and over..	11	OCTOBER.	
and over ..	2	3 feet and over..	30	10 feet and over..	5		
		4 feet and over..	30	11 feet and over..	3	1 foot and over..	31
RUARY.		5 feet and over..	19			2 feet and over..	19
		6 feet and over..	15	JULY		3 feet and over..	5
and over ..	28	7 feet and over..	14				
and over ..	28	8 feet and over..	14	1 foot and over..	31	NOVEMBER.	
and over ..	28	9 feet and over..	12	2 feet and over..	31		
and over ..	28	10 feet and over..	5	3 feet and over..	31	1 foot and over..	24
and over ..	28	11 feet and over..	2	4 feet and over..	24	2 feet and over..	6
and over ..	28			5 feet and over..	16		
and over ..	28	MAY.		6 feet and over..	12	DECEMBER.	
and over ..	28			7 feet and over..	9		
and over ..	21	1 foot and over..	31	8 feet and over..	7	1 foot and over..	29
and over ..	13	2 feet and over..	31	9 feet and over..	5	2 feet and over..	17
and over ..	10	3 feet and over..	31	10 feet and over..	4	3 feet and over..	1
and over ..	8	4 feet and over..	31				

Total for the year from January 1 *to December* 31, 1874.

l for twelve months.		Total for twelve months.		Total for twelve months.		Total for twelve months.	
Height.	No. of days.	Height.	No. of days.	Height.	No. of days.	Height.	No. of days.
et and over ...	357	7 feet and over..	152	13 feet and over..	31	19 feet and over..	3
et and over ...	315	8 feet and over..	136	14 feet and over..	22	20 feet and over..	3
et and over ...	280	9 feet and over..	113	15 feet and over..	10	21 feet and over..	2
et and over ...	247	10 feet and over..	83	16 feet and over..	6	22 feet and over..	2
et and over ...	217	11 feet and over..	62	17 feet and over..	5	23 feet and over..	2
et and over ...	180	12 feet and over..	42	18 feet and over..	3		

TABLES APPENDED.

There are also appended to this report the following tables, belonging more properly to the first part of it, relating to the surveys, but which were not prepared when that was transmitted:

Table of recorded heights of remarkable freshets in the Connecticut River above low-water at Hartford.

Table of borings between Hartford and Holyoke, showing the strata passed through.

General list of bench-marks between Hartford and Holyoke.

List of high-water marks between Hartford and Holyoke.

Table showing heights of freshets in the Connecticut River above low-water at Hartf

Date.	Height above 0 of gauge.	Date.
	Feet.	
Freshet of 1801	27.50	Freshet of April, 1862
Freshet of 1841	26.33	Freshet of November, 1862
Freshet of 1843	27.17	Freshet of May, 1863
Freshet of December, 1844	19.50	Freshet of April, 1864
Freshet of February, 1845	19.00	Freshet of March, 1865
Freshet of April, 1845	19.00	Freshet of May, 1865
Freshet of March, 1846	18.75	Freshet of February, 1866
Freshet of April, 1847	21.00	Freshet of April, 1866
Freshet of January, 1848	15.50	Freshet of February, 1867
Freshet of November, 1849	17.50	Freshet of April, 1867
Freshet of May, 1850	20.75	Freshet of August, 1867
Freshet of January, 1851	14.50	Freshet of March, 1868
Freshet of April, 1852	23.12	Freshet of April, 1869
Freshet of May, 1853	16.00	Freshet of October, 1869
Freshet of November, 1853	20.50	Freshet of February, 1870
Freshet of May, 1854	29.83	Freshet of April, 1870
Freshet of January, 1855	15.00	Freshet of March, 1871
Freshet of April, 1856	16.25	Freshet of May, 1871
Freshet of August, 1856	23.33	Freshet of April, 1872
Freshet of February, 1857	19.50	Freshet of June, 1872
Freshet of October, 1857	18.25	Freshet of August, 1872
Freshet of March, 1858	12.25	Freshet of November, 1872
Freshet of March, 1859	26.42	Freshet of April, 1873
Freshet of March, 1860	16.00	Freshet of October, 1873
Freshet of April, 1861	21.50	Freshet of January, 1874

Table of borings in river-bed between Hartford and Holyoke.

Boring No. 1, opposite State street, Hartford.

Thickness of stratum.	Total depth.	Material passed through.
′ ″	′ ″	
23 0	23 0	Sandy loam.
9 2	32 2	Red clay and sand.
7 10	40 0	Red clay.
6 6	46 6	Red clay and sandy loam.
3 0	49 6	Red clay and gravel.

Struck a root or log.

Boring No. 2, east side of river, 0.63 mile above Hartford.

14 0	14 0	Sandy loam.
4 2	18 2	Sand and clay.
0 10	19 0	Hard sand.
10 9	29 9	Quicksand.
17 9	47 6	Quicksand and red clay.
3 0	50 6	Red clay and gravel.

Hard red marl, which prevented boring.

Boring No. 3, east side of river, 1.56 miles above Hartford.

4 6	4 6	Sandy loam.
5 6	10 0	Sand and hard clay.
11 0	21 0	Soft wet sand.
3 0	24 0	Blue sand and clay.
3 1	27 1	Coarse sand.
23 5	50 6	Coarse sand and clay.
16 0	66 6	Clay and fine sand.
23 6	90 0	Clay and coarse sand.

Sand filled the hole as fast as bored.

Boring No. 4, west side of river, 2.39 mile Hartford.

29 0	29 0	Sandy loam.
1 9	30 9	Blue sand and loam.
8 0	38 9	Sand and gravel.
5 3	44 0	Clay and gravel.
36 0	80 0	Red clay.
42 6	122 6	Yellow sand.
0 10	123 4	Red marl and gravel.

Hard; probably rock.

Boring No. 5, west side of river, 3.37 mile Hartford.

4 2	4 2	Sandy loam.
4 8	8 10	Clay and sand.
8 0	16 10	Sand and mud.
0 5	17 3	Sand and gravel.
4 8	21 11	Red clay and gravel.

Rock.

Boring No. 6, west side of river, 4.48 mile Hartford.

2 0	2 0	Dark loam.
2 6	4 6	Sand and clay.
2 6	7 0	Red gravel and shelly rock
1 2	8 2	Hard red clay.
25 2	33 4	Soft red clay.
1 4	34 8	Red clay and gravel.

Rock.

Table of borings in river-bed between Hartford and Holyoke—Continued.

Boring No. 7, west side of river, 5.24 miles above Hartford.

Thickness of stratum.	Total depth.	Material passed through.
′ ″	′ ″	
10 8	10 8	Sandy loam.
8 9	19 5	Yellow mud.
1 9	21 2	Gray sand.
25 3	46 5	Yellow sand.
5 10	52 3	Red gravel.

Rock.

Boring No. 8, west side of river, 6.27 miles above Hartford.

2 10	2 10	Sandy loam.
17 3	20 1	River sand.
3 4	23 5	Shelly rock and gravel.
6 7	30 0	Sand and gravel.
4 2	34 2	River sand.
2 4	36 6	Red clay and gravel.
33 6	70 0	Red clay.
2 4	72 4	Red clay and gravel.
4 2	76 6	Red sand.

Hole filled up as fast as bored.

Boring No. 9, east side of river, 7.23 miles above Hartford.

12 7	12 7	Coarse sand.
0 8	13 3	Sand and gravel.

Rock.

Boring No. 10, west side of river, 8.18 miles above Hartford.

2 6	2 6	Dark loam.
3 10	6 4	Yellow loam.
10 2	16 6	Yellow loam and clay.
2 0	18 6	Blue clay.
2 0	20 6	Sand and gravel.
1 1	21 7	Shelly rock.

Rock.

Boring No. 11, west side of river, 8.93 miles above Hartford.

3 1	3 1	Sandy loam.
7 11	11 0	Coarse sand and loam.
0 7	11 7	Gravel and sand.

Rock.

Boring No. 12, west side of river, 9.64 miles above Hartford.

6 6	6 6	Sandy loam.
3 4	9 10	Gray sand.
0 6	10 4	Red gravel.

Rock.

Boring No. 13, west side of river, 10.49 miles above Hartford.

4 9	4 9	Yellow sandy loam.
14 7	19 4	Gray sand and loam.
0 8	20 0	River sand.
1 4	21 4	Gravel and shelly rock.

Rock.

Boring No. 14, west side of river, 10.85 miles above Hartford.

5 4	5 4	Sandy loam.
11 0	16 4	Red clay and gravel.

Boring stopped; probably rock.

Boring No. 15, east side of river, 18.39 miles above Hartford.

1 6	1 6	Dark loam.
5 3	6 9	Clay and fine sand.
7 5	14 2	Red clay and gravel.

Rock.

Boring No. 16, east side of river, 19.54 miles above Hartford.

5 0	5 0	Dark loam.
6 11	11 11	Yellow and gray sand.
3 10	15 9	Yellow and blue sand.
14 1	29 10	River sand and gravel.

Sand filled the hole as fast as bored.

Boring No. 17, east side of river, 20.61 miles above Hartford.

9 10	9 10	Yellow loam.
6 8	16 6	Yellow sand.
1 10	18 4	River sand.
45 11	64 3	Sand and gravel.
3 10	68 1	Fine sand and clay.
15 11	84 0	Coarse gravel and sand.
13 0	97 0	Sand and gravel.
4 4	101 4	Fine sand.

Auger lost in hole.

Boring No. 18, east side of river, 24.96 miles above Hartford.

9 0	9 0	Sandy loam.
25 6	34 6	River and blue sand.
1 0	35 6	Coarse gravel and sand.
14 9	50 3	Gravel and river sand.

Rock.

Boring No. 19, east side of river, 28.60 miles above Hartford.

4 6	4 6	Sandy loam.
12 11	17 5	Loam and gray sand.
27 7	45 0	Fine river sand.
2 6	47 6	Gravel and sand.

Auger lost in hole.

List of bench-marks between Hartford and Holyoke.

	Feet.
Low-water mark at Hartford, or 0 of the gauge at the toll-bridge	.000
Top of freestone foundation at the northeast corner of house on the southwest corner of Warwarme avenue and Van Dyke avenue, Hartford	31.540
Cut on the west side of an elm tree, near the northwest corner of Deming's collar-shop, in East Hartford	32.613
Cut on the west side of a double apple-tree, 90 feet south of the southeast corner of old poudrette factory, and 640 feet east of main road in East Hartford	34.991

	Feet.
Cut on south side of black-oak stump, 200 feet northwest of the northwest corner of the barn in John Whalen's lot, East Hartford	31.943
Cut on maple tree, 1,270 feet west of southwest corner of a road to the meadows, said corner being about 2,650 feet north of Podunk River bridge, on main road in South Windsor	34.055
Cut on south side of maple tree, 520 feet west of the main road, and 1,230 feet south of Stoughton's Brook in John Moore's lot, South Windsor	23.344
Cut on east side of locust tree, on the north side of road to Bissell's ferry, and 510 feet west of main road in South Windsor	65.840
Cut and spike on north side of northerly pine tree, about 60 feet northwest from town-house at Bissell's ferry	28.310
Cut on the south side of hickory tree, 210 feet northwest of the northwest corner of tobacco-shed in Charles Well's lot, East Windsor	50.704
Cut on the northwest side of a large hickory tree, about 900 feet northeast of the mouth and 100 feet west of Prior's Creek, East Windsor	27.152
Northeast corner of underpinning stone at the northeast corner of red tobacco-shed belonging to J. C. Bassenger, on west side of river road at Warehouse Point	29.810
Top of southwest corner of abutment of New York, New Haven and Hartford Railroad bridge at Warehouse point	61.900
Top of southeast corner of abutment of New York, New Haven and Hartford Railroad bridge at Windsor Locks	61.750
Top of northeast corner of north end of capping to east wall of brick arch bridge, over second road south of Thompsonville station, on New York, New Haven and Hartford Railroad, being about 300 feet south of the southwest corner of said station	76.663
Southwest corner of stone in top course of west wall of the second culvert north of Thompsonville station, and first south of Longmeadow station	56.40
Top of black brick in the middle of the top of south arch of culvert under road from the village to Longmeadow station, about 150 feet east of railroad track	55.02
Apex of cap-stone to third post in wall north granite post marking boundary between Springfield and Longmeadow, at Pecowsic	68.1
Top of southwest corner of stone in top course of brick arch bridge on west side of railroad, marked with two cuts and also △ $4 . First bridge north of Pecowsic	63.2
Southeast corner of top stone in upper course of east wall of culvert at the foot of Elm street in Springfield, about 15 feet northwest of Gas Company's building	61.7
Northwest corner of stone underpinning of south side of south door in west end of passenger station in Springfield, Mass	71.3
Southeast corner of south end of top course of stone in culvert under railroad, first north of Hampden Park, and about 400 feet south of first mile-stone on east side of Connecticut River Railroad	60.6
Northeast corner of top stone of south wall of first culvert north of first cross-road, north of second mile-stone from Springfield, on east side of Connecticut River Railroad	67.1
North corner of fourth mile-stone from Springfield, on Connecticut River Railroad	67.6
North corner of sixth mile-stone from Springfield, on Connecticut River Railroad	70.2
Southwest corner of south abutment of Connecticut River Railroad bridge at Willimansett, Mass. Stone is in foot-bridge	78.1
Point marked with white paint and "110" on southeast corner of foundation to south side of pump-house, near Holyoke dam, at the head of a flight of stone steps	107.97

Table of high-water marks.

Low water at Hartford	.0
1854—High water at Hartford	29.8
1854—High-water mark, an iron pin in north side of maple tree about 600 feet west of main road, near S. B. Newburry's house, South Windsor	21.0
1854—High-water mark by Mrs. Craw, in house now owned by Mrs. Ellen Blodgett, near Bissell's ferry, South Windsor	32.56
1854—High-water mark at foot of canal, Windsor Locks	32.8
1854—High-water mark by Mr. Seymour King, on sill of front door of his house, Windsor Locks	33.31
1854—High-water mark made by Mr. Levi Palmer in his barn, at Warehouse Point	32.73

	Feet.
High-water mark made by Mr. Levi Palmer in his barn, at Warehouse Point	33.18
High-water mark made by Mr. Levi Palmer in his woodshed, at Warehouse Point	32.82
High-water mark made by Mr. Hayden at the silk-factory, Windsor Locks	32.71
High-water mark at same place	32.62
High-water mark at same place	32.96
High-water mark at same place	32.87
High-water mark at same place	31.62
High-water mark at same place	31.66
High-water mark on shed, by Mrs. Conroy, Windsor Locks	31.42
High-water mark shown by Mrs. George Miller, on step of house, Warehouse Point	32.38
High-water mark on outbuilding, by George Gleason, Warehouse Point.	32.06
High-water mark shown by J. Schœnansgruber, Warehouse Point	32.88
High-water mark by Mr. Douglass, on house south of ferry-slip, Windsor Locks	30.55
High-water mark in bar-room of American House, Warehouse Point	32.92
High-water mark shown by Mrs. Finkeldey, Warehouse Point	31.12
High-water mark shown by Mrs. Finkeldey, Warehouse Point	30.84
High-water mark by Mr. Sexton, on seventh pier of railroad-bridge, Warehouse Point	32.12
High-water mark on stone near Mr. Fowler's house, Windsor Locks	2.
357—High-water marks by Mr. Hemingway, on Powder Company's building, Enfield. It is supposed the shed has settled about one inch, so as to make the two marks agree	41.45
High-water mark shown by Mr. Sullivan, on gate of north lock of canal, Sheffield	49.41
High-water mark shown by George Douglass, on upper one of four spikes on south side of elm tree, on south bank of first brook south of Thompsonville Ferry, on west bank of Connecticut River	54.16
High-water mark, top of third brick from north end in top course on the west side of brick culvert over brook from factories in Thompsonville, between the brick-arched bridges over roads just south of Thompsonville station	55.61
High-water mark on northeast corner of top brownstone post, corner of York and South Main streets, Springfield, on line with York-street fence of Mr. Call's estate, and about 3 feet from iron lamp-post on said corner. The post is now 6 inches under ground at edge of brick sidewalk	59.69
High-water mark on the horizontal line of a cross-cut in the south side of top stone on the southwest corner of old east abutment of carriage bridge, Springfield, marked on next stone east "1854 flood"	59.91
High-water mark on top of east end of back board to top step to basement, at the north end of P. Harrington's house, at the foot of Union street, south side, between the railroad and Connecticut River, Springfield	60.52
High-water mark with red paint, on northwest corner of easterly abutment of railroad-bridge, Springfield	60.36
High-water mark same place as above	58.75
High-water mark on merestone on west side of Main street, at northeast corner of fence north of Mr. Sike's house, West Springfield	61.29
High-water mark on right outer corner of door-sill on the west side of Mrs. Beebe's house, on east side of Main street, West Springfield	61.39
High-water mark on centre of front edge of top step of Dr. H. C. Belden's house, West Springfield	63.10
High-water mark on stone at foot of Westfield street, West Springfield.	63.21
High-water mark on stone mentioned above	61.50
High-water mark on stone mentioned above	62.04
High-water mark on south side of sycamore tree at south end of shed, north of Riverdale Mill, West Springfield	63.88
High-water mark on nail in south side of brick foundation of R. A. Bagg's house, 1,000 feet south of cross-roads, on east side of Main street, West Springfield	62.96
High-water mark on centre of white-paint mark on south side of first pier on east side of Cabot bridge, Chicopee	62.99
High-water mark same place as above	63.28
High-water mark on northwest corner of brick foundation at Ames's Works, Chicopee	63.46

1854—High-water mark 14 inches above floor of room in house, formerly a saw-mill, adjoining grist-mill of R. Brock on south end. The second building from Willimansett station on east side of road from station to South Hadley Falls, shown by R. Brock, who has lived here forty-two years.....

1869—High-water mark, upper notch of two notches cut in corner of board partition of office, in northeast corner of Brierly & Allen's Brewery, the third building on east side of road from Willimansett station on road to South Hadley Falls .....

1868—High-water mark is the lower of the above-mentioned notches .....

1862—High-water mark painted black on northwest corner of brick store-house next west of gasometer belonging to the Glascow Thread Company, and shown by B. Hadley, who marked it; he says the high water of 1854 was 18 inches below that of 1862. Mr. Gaylord, of South Hadley Falls, says the same.....

1862—High-water mark inside of gate-house of Holyoke Dam, top of second casting from end of house nearest end of dam supporting gearing for raising first gate, shown by M. O'Donald, employed by the Holyoke Water-Power Company in 1862..... 1

List of maps, drawings, &c., accompanying the report.

1. Map of the Connecticut River from Hartford to Holyoke in six sheets.
2. Diagram of borings in the bed of the river.
3. Profile of the Connecticut River from Hartford to Holyoke, showing high low water.
4. Diagram showing the cross-sections of the river at Thompsonville.
5. Three sheets of drawing of apparatus used in gauging.
6. Three sheets of plotted current-velocities taken at Thompsonville.
7. Diagram of mean vertical curves of current-velocities at Thompsonville.
8. Diagram showing the height of river at Hartford from February 1 to Dece 31, 1871.
9. Diagram showing the height of river at Hartford from January 1 to Dece 31, 1872.
10. Diagram showing the height of river at Hartford from January 1 to Dece 31, 1873.
11. Diagram showing the height of river at Hartford from January 1 to Dece 31, 1874.
12. Tracing for the purpose of placing the lines of gauging at Thompsonville the map transmitted with the first part of this report.
13. Three field-books are also transmitted, containing the notes of the levels, s ings, current-observations, and heights of water, taken at Thompsonville in 187
14. Diagram showing curve formed by using the computed volumes at Thom ville as abscissas and the height of the water as ordinates.
15. Diagram showing two curves, both having the dates as abscissas, with th umes as the co-ordinates of one curve, and height of the river as the ordinate o other.

DESCRIPTION OF FIGURES IN DIAGRAM OF VERTICAL CURVES OF CURRENT-VELOC AT THOMPSONVILLE, CONN.

Means obtained by computation.

Fig. 1. Mean of meter-observations below average velocity of 1.86.
Fig. 2. Mean of float-observations below average velocity of 1.86.
Fig. 3. Mean of all observations below average velocity of 1.86.
Fig. 4. Mean of meter-observations above average velocity of 1.86.
Fig. 5. Mean of float-observations above average velocity of 1.86.
Fig. 6. Mean of all observations above average velocity of 1.86.
Fig. 7. Mean of all meter-observations.
Fig. 8. Mean of all float-observations.
Fig. 9. Mean of all meter and float observations.
Fig. 10 is Fig. 1 reduced to average velocity 1.
Fig. 11 is Fig. 2 reduced to average velocity 1.
Fig. 12 is Fig. 3 reduced to average velocity 1.
Fig. 13 is Fig. 4 reduced to average velocity 1.
Fig. 14 is Fig. 5 reduced to average velocity 1.
Fig. 15 is Fig. 6 reduced to average velocity 1.
Fig. 16 is Fig. 7 reduced to average velocity 1.
Fig. 17 is Fig. 8 reduced to average velocity 1.
Fig. 18 is Fig. 9 reduced to average velocity 1.

Means obtained by graphic methods.

Fig. 19. Mean curve by meter No. 1 on section at F, mean velocity being 1.
Fig. 20. Mean curve by meter No. 1 on section at G, mean velocity being 1.
Fig. 21. Mean curve by meter No. 2 on section at G, mean velocity being 1.
Fig. 22. Mean curve by meter No. 1 on section at B, mean velocity being 1.
Fig. 23. Mean curve by meter No. 1 on section at C, mean velocity being 1.
Fig. 24. Grand mean of meter-observations, mean velocity being 1.
Fig. 25. Mean curve by floats on section at F, mean velocity being 1.
Fig. 26. Mean curve by floats on section at G, mean velocity being 1.
Fig. 27. Grand mean of float-observations, mean velocity being 1.
All of which is respectfully submitted.

THEO. G. ELLIS,
Civil Engineer.

Gen. G. K. WARREN,
Major of Engineers, U. S. A.

The maps and drawings submitted with the foregoing report are mostly upon a large scale, unsuitable for printing. They have been, therefore, somewhat modified and reduced in size, to enable them to be shown in the accompanying plates.

Of the maps and diagrams named in the foregoing list—

No. 1 is reduced to about one-third of the original scale, and the six sheets are shown in plates Nos. I, II, and III.

No. 2, reduced in size, is shown in Plate IV.

No. 3, reduced in scale, is shown in Plate V.

No. 4, reduced in scale, is shown in Plate VI.

No. 5 is shown in Plate VII.

No. 6 is omitted from the plates, as the ordinates of the current velocities are given in the tables, and can be easily plotted if desired.

No. 7 is shown in Plate VI.

No. 8 is shown to a reduced scale in Plate VIII.

No. 9 is shown to a reduced scale in Plate IX.

No. 10 is shown to a reduced scale in Plate X.

No. 11 is shown to a reduced scale in Plate XI.

No. 12 is placed upon the general map, Plates I, II, and III.

No. 13. These books are too voluminous to be reproduced.

No. 14 is shown in Plate XIII.

No. 15 is shown in Plate XIII.

The description given for the diagram of vertical curves of current velocities at Thompsonville applies to the figures in Plate VI.

ADDITIONAL TABLES OF HEIGHT AND DISCHARGE.

The observations of the height of the river have been continued during the year since the foregoing report was made, and the following supplementary tables have been prepared, bringing the record of the discharge of the river up to January 1, 1876.

During the years 1871 to 1874, inclusive, the height of the water was taken daily by means of a gauge at the toll-bridge from Hartford to East Hartford. The bridge company's gauge was upon the toll-house, and extended from 11 to 30 feet in height. The zero of this gauge, or 12 feet below the 12-foot mark, was taken as low-water and the base for the levels. A gauge from 0 to 12 feet was placed upon the first pier, opposite the bridge-gauge, and all heights below 12 feet were read upon it. Sometimes in winter it would be incased in ice, and, being in an exposed position, it was several times carried away by floating ice, but was carefully replaced at the same level. At such times the readings below 11 feet were taken by a gauge upon a pile at the steamboat-dock near the foot of State street, which was compared by levels with the toll-bridge gauge.

These levels were as follows :

Eleven-foot mark on gauge on pile at steamboat-dock—

By Mr. Gelette, in April, 1871	11.191
By Mr. Burdett, in March, 1874	11.205
By Mr. Curtis, in December, 1874	11.194

The distance between the two gauges is about 1,750 feet.

At the beginning of the year 1875 the gauge upon the pier was covered with ice, and in the spring it was carried away, so that the readings below 11 feet were taken at the steamboat-dock gauge up to August 10. The gauge upon the toll-house belonging to the bridge company having been taken down, painted, cut in two, and replaced in a slightly different position, it was determined to set a new gauge at the steamboat-dock corresponding to the exact zero of the previous observations. This was done on August 10, a new gauge, consisting of three 10-foot lengths, being set up in the following manner: The first 10 feet was placed upon a pile at the north end of the steamboat-wharf, in a sheltered position where the next wharf above projects, so that the gauge faces downstream. The second 10 feet was placed upon a tall clump of piles

east of the steamboat store-house, and the upper 10 feet was spiked to the north s of the store-house itself.

The height of these gauges and the former one at the bridge is referred to the lowing bench-marks, so that either could be readily replaced at the same height:

Top of an iron eyebolt let into the masonry of the northeast corner pier of steamboat store-house; height above zero, 14.150 feet.

Southeast corner of stone door-sill on south side of soap-factory building, No Morgan street; height above zero, 26.555 feet.

Since August 10 the readings have all been taken upon the new gauge at the st boat-wharf.

Table showing the daily discharge and height of the Connecticut River at Hartford January 1 to December 31, 1875.

Date.	Height, feet.	Millions of cubic feet.	Date.	Height, feet.	Millions of cubic feet.	Date.	Height, feet.	Milli cubi
1875.			1875.			1875.		
Jan. 1	2.01	562	Mar. 1	7.99	2,300	May 1	10.91	
2	2.07	569	2	7.59	2,129	2	10.80	
3	1.74	542	3	6.77	1,824	3	12.20	
4	2.07	569	4	6.52	1,728	4	13.42	
5	2.53	649	5	5.72	1,447	5	12.57	
6	2.05	567	6	5.50	1,374	6	11.22	
7	2.13	575	7	6.08	1,588	7	10.82	
8	2.29	608	8	5.23	1,284	8	12.96	
9	2.24	602	9	5.00	1,218	9	13.21	
10	1.23	495	10	4.80	1,160	10	12.52	
11	1.23	495	11	4.80	1,160	11	13.11	
12	1.35	507	12	4.44	1,058	12	13.87	
13	1.87	549	13	4.49	1,070	13	14.01	
14	2.02	563	14	4.55	1,085	14	14.21	
15	1.17	489	15	4.62	1,103	15	14.23	
16	1.34	502	16	5.63	1,417	16	13.78	
17	1.41	510	17	7.28	2,003	17	13.24	
18	1.84	551	18	8.21	2,392	18	12.19	
19	2.16	590	19	8.39	2,465	19	11.08	
20	2.09	579	20	7.94	2,280	20	9.90	
21	1.89	557	21	7.21	1,975	21	9.08	
22	1.88	554	22	6.52	1,723	22	8.74	
23	1.79	547	23	5.92	1,508	23	8.88	
24	1.88	554	24	5.52	1,377	24	8.74	
25	2.01	562	25	5.20	1,476	25	8.46	
26	1.84	551	26	4.74	1,138	26	8.51	
27	1.24	496	27	4.73	1,136	27	8.06	
28	1.49	516	28	4.96	1,042	28	7.43	
29	2.14	580	29	5.57	1,388	29	7.06	
30	1.62	530	30	6.46	1,698	30	6.48	
31	1.98	559	31	7.98	2,486	31	5.78	
		17,079			49,032			
Feb. 1	2.09	570	Apr. 1	10.03	3,175	June 1	5.30	
2	1.89	540	2	11.60	3,874	2	4.91	
3	2.19	583	3	13.77	4,926	3	4.61	
4	3.38	793	4	15.47	5,793	4	4.32	
5	3.62	850	5	18.00	7,315	5	4.02	
6	3.48	821	6	18.73	7,771	6	3.71	
7	3.66	864	7	17.42	6,937	7	3.77	
8	3.72	870	8	16.04	6,142	8	3.52	
9	3.76	874	9	14.61	5,341	9	3.81	
10	3.23	772	10	12.99	4,540	10	3.91	
11	3.55	834	11	13.75	4,899	11	4.05	
12	4.03	950	12	16.17	6,183	12	3.95	
13	3.74	878	13	15.89	6,040	13	3.63	
14	3.41	806	14	13.97	5,016	14	3.41	
15	2.92	712	15	12.15	4,151	15	3.10	
16	2.83	702	16	12.08	4,112	16	2.99	
17	2.66	662	17	15.73	6,013	17	2.93	
18	2.41	623	18	18.27	7,497	18	3.41	
19	2.41	623	19	17.46	6,960	19	3.26	
20	2.74	678	20	15.08	5,562	20	6.50	
21	2.46	629	21	12.07	4,110	21	7.91	
22	2.42	624	22	10.24	3,300	22	8.71	
23	2.48	631	23	9.03	2,719	23	8.66	
24	3.31	779	24	8.63	2,579	24	7.71	
25	6.13	1,584	25	9.56	2,958	25	6.40	
26	8.45	2,498	26	10.69	4,472	26	5.06	
27	9.01	2,714	27	11.25	3,730	27	4.63	
28	8.62	2,550	28	11.13	3,685	28	4.28	
			29	11.05	3,654	29	4.16	
			30	10.95	3,595	30	4.14	
		27,023			146,049			

showing daily discharge and height of Connecticut River during 1875, *&c.*—Continued.

ate.	Height, feet.	Millions of cubic feet.	Date.	Height, feet.	Millions of cubic feet.	Date.	Height, feet.	Millions of cubic feet.
875.			1875.			1875.		
1	3. 82	884	Sept. 1	2. 42	624	Nov. 1	7. 56	2; 124
2	3. 52	833	2	2. 42	624	2	8. 43	2, 497
3	3. 48	821	3	2. 36	616	3	7. 95	2, 296
4	3. 24	773	4	2. 44	626	4	6. 95	1, 875
5	3. 05	740	5	2. 01	562	5	5. 92	1, 525
6	3. 16	756	6	1. 95	556	6	5. 22	1, 286
7	3. 71	869	7	1. 62	530	7	4. 59	1, 091
8	4. 33	1, 025	8	1. 40	507	8	4. 10	964
9	3. 80	882	9	1. 20	492	9	4. 05	954
10	4. 00	947	10	1. 31	500	10	4. 08	960
11	3. 89	918	11	1. 55	522	11	4. 94	1, 198
12	3. 54	839	12	1. 87	549	12	5. 75	1, 455
13	3. 51	830	13	1. 78	545	13	5. 69	1, 432
14	3. 48	821	14	1. 80	547	14	5. 41	1, 344
15	3. 23	772	15	1. 92	556	15	5. 32	1, 311
16	3. 06	742	16	2. 38	618	16	5. 50	1, 370
17	3. 94	925	17	2. 43	626	17	5. 40	1, 335
18	2. 82	686	18	2. 56	652	18	5. 45	1, 359
19	2. 49	632	19	2. 84	688	19	5. 22	1, 288
20	2. 07	569	20	2. 91	706	20	4. 90	1, 181
21	2. 21	599	21	2. 56	651	21	4. 51	1, 066
22	2. 79	682	22	1. 98	559	22	4. 22	1, 001
23	2. 87	692	23	1. 90	552	23	4. 18	991
24	2. 62	658	24	1. 96	557	24	3. 83	892
25	2. 43	625	25	2. 01	562	25	3. 94	925
26	2. 14	576	26	2. 03	563	26	4. 11	970
27	1. 98	559	27	1. 96	557	27	4. 67	1, 120
28	2. 03	564	28	2. 03	563	28	6. 86	1, 838
29	2. 13	575	29	2. 29	609	29	7. 39	2, 050
30	2. 20	598	30	2. 54	649	30	5. 38	1, 324
31	2. 21	599						
		22, 991			17, 468			41, 022
Aug. 1	2. 03	564	Oct. 1	2. 32	612	Dec. 1	7. 15	1, 971
2	2. 09	571	2	2. 22	600	2	7. 03	1, 922
3	2. 34	614	3	2. 63	659	3	6. 97	1, 885
4	2. 59	655	4	3. 73	871	4	6. 58	1, 748
5	3. 28	777	5	4. 03	950	5	6. 45	1, 687
6	4. 20	985	6	3. 80	882	6	6. 33	1, 671
7	4. 34	1, 026	7	3. 74	872	7	6. 20	1, 610
8	4. 08	960	8	3. 18	751	8	6. 15	1, 586
9	3. 45	812	9	3. 47	810	9	5. 97	1, 526
10	3. 24	762	10	3. 90	920	10	5. 58	1, 390
11	2. 95	717	11	4. 37	1, 040	11	5. 23	1, 281
12	4. 63	1, 109	12	4. 39	1, 042	12	5. 07	1, 236
13	6. 83	1, 830	13	4. 26	1, 012	13	5. 67	1, 425
14	5. 87	1, 495	14	4. 00	933	14	4. 39	1, 042
15	5. 39	1, 339	15	4. 17	977	15	3. 78	881
16	4. 84	1, 162	16	4. 17	977	16	4. 20	988
17	4. 28	1, 014	17	3. 82	884	17	4. 20	988
18	4. 47	1, 068	18	4. 05	954	18	3. 15	750
19	7. 78	2, 219	19	4. 20	988	19	3. 08	742
20	8. 06	2, 323	20	4. 17	981	20	3. 27	769
21	6. 84	1, 831	21	3. 96	924	21	3. 28	770
22	5. 58	1, 394	22	3. 72	870	22	3. 30	774
23	4. 44	1, 058	23	3. 33	780	23	3. 75	878
24	3. 72	874	24	3. 27	771	24	4. 85	1, 170
25	3. 20	760	25	3. 32	782	25	6. 05	1, 570
26	2. 85	704	26	3. 67	865	26	6. 70	1, 799
27	2. 76	681	27	3. 28	772	27	6. 70	1, 799
28	2. 88	708	28	3. 62	856	28	6. 72	1, 801
29	2. 58	654	29	3. 76	880	29	7. 40	2, 060
30	2. 54	650	30	4. 42	1, 050	30	7. 36	2, 044
31	2. 59	655	31	4. 69	1, 122	31	6. 81	1, 820
		31, 971			27, 387			43, 583

Totals for the months and year.

1875.	Cubic feet.	1875.	Cubic feet.
January	17, 079, 000, 000	August	31, 971, 000, 000
February	27, 023, 000, 000	September	17, 468, 000, 000
March	49, 032, 000, 000	October	27, 387, 000, 000
April	146, 049, 000, 000	November	41, 022, 000, 000
May	111, 437, 000, 000	December	43, 583, 000, 000
June	35, 607, 000, 000		
July	22, 991, 000, 000	Total	570, 649, 000, 000

Table showing the number of days in 1875 that the average for the day at Hartford was ab
a given height.

Height.	No. of days.	Height.	No. of days.	Height.	No. of days.	Height.	No. day
JANUARY.		2 feet and over..	30	12 feet and over..	14	SEPTEMBER.	
		3 feet and over..	30	13 feet and over..	9		
1 foot and over ..	31	4 feet and over..	30	14 feet and over..	3	1 foot and over..	
2 feet and over ..	13	5 feet and over..	30			2 feet and over..	
		6 feet and over..	30	JUNE.			
FEBRUARY.		7 feet and over..	30			OCTOBER.	
		8 feet and over..	30	1 foot and over..	30		
1 foot and over ..	28	9 feet and over..	29	2 feet and over..	30	1 foot and over..	
2 feet and over ..	27	10 feet and over..	27	3 feet and over..	28	2 feet and over..	
3 feet and over ..	16	11 feet and over..	23	4 feet and over..	17	3 feet and over..	
4 feet and over ..	5	12 feet and over..	19	5 feet and over..	7	4 feet and over..	
5 feet and over ..	4	13 feet and over..	15	6 feet and over..	5		
6 feet and over ..	4	14 feet and over..	12	7 feet and over..	3	NOVEMBER.	
7 feet and over ..	3	15 feet and over..	11	8 feet and over..	2		
8 feet and over ..	3	16 feet and over..	7			1 foot and over..	
9 feet and over ..	1	17 feet and over..	5	JULY.		2 feet and over..	
		18 feet and over..	3			3 feet and over..	
MARCH.				1 foot and over..	31	4 feet and over..	
		MAY.		2 feet and over..	30	5 feet and over..	
1 foot and over ..	31			3 feet and over..	17	6 feet and over..	
2 feet and over ..	31	1 foot and over..	31	4 feet and over..	2	7 feet and over..	
3 feet and over ..	31	2 feet and over..	31			8 feet and over..	
4 feet and over ..	31	3 feet and over..	31	AUGUST.			
5 feet and over ..	22	4 feet and over..	31			DECEMBER.	
6 feet and over ..	13	5 feet and over..	31	1 foot and over..	31		
7 feet and over ..	8	6 feet and over..	30	2 feet and over..	31	1 foot and over..	
8 feet and over ..	2	7 feet and over..	29	3 feet and over..	20	2 feet and over..	
		5 feet and over..	27	4 feet and over..	15	3 feet and over..	
APRIL.		9 feet and over..	21	5 feet and over..	7	4 feet and over..	
		10 feet and over..	19	6 feet and over..	4	5 feet and over..	
1 foot and over ..	30	11 feet and over..	16	7 feet and over..	2	6 feet and over..	
				8 feet and over..	1	7 feet and over..	

Totals for the year from January 1 to December 31, 1875.

Total for twelve months.		Total for twelve months.		Total for twelve months.		Total for twelve month	
Height.	No. of days.	Height.	No. of days.	Height.	No. of days.	Height.	No. day
1 foot and over ..	365	6 feet and over..	107	11 feet and over..	39	15 feet and over..	
2 feet and over ..	331	7 feet and over..	83	12 feet and over..	33	16 feet and over..	
3 feet and over ..	261	8 feet and over..	66	13 feet and over..	24	17 feet and over..	
4 feet and over ..	198	9 feet and over..	51	14 feet and over..	15	18 feet and over..	
5 feet and over ..	138	10 feet and over..	46				

TIDES AT HARTFORD.

In connection with the observations of the height of the river by the gauge at H ford, a continuous reading for some months was made with a self-registering tide-ga during the summer of 1874, for the purpose of obtaining the laws of the tides at place during the season of lowest water.

This gauge was set up at the freight-house of the Hartford, New Haven and Sp field Railroad, and remained there during the low-water from June to Novembe selection of two full lunations was made, from August 27 to October 25, when the w was lowest, for the purpose of determining the extent and character of the tides; a general tide-table has been computed from the observed fluctuations which will a to the river at its lowest stages.

The tides at Hartford rapidly disappear as the river rises, although they are pe tible by the self-registering apparatus up to about eight feet. To ordinary obse tion they disappear at about five feet above lowest water.

In the summer of 1872, a series of tide-observations was made at the mouth o river, with a self-registering gauge, from which the laws of the tides at that point determined with great accuracy. They furnish the means of comparing the tid Saybrook and Hartford, and showing their difference of height and rate of progre the river, with more than ordinary exactness. A diagram (Plate XIV) showing two lunations before mentioned, has been prepared to accompany this report. It s

curves of the tides; also the daily time of the moon's southing; the time of the on's changes; the points of north, south, and zero declination; and the time of igee and apogee; all of which has been carefully computed from the American hemeris for the latitude and longitude of Hartford. The following table has been pared, showing the characteristics of the tides at Hartford, to which is added such rticulars relating to the tides at the mouth of the river as will assist in determining e changes in the tidal wave as it progresses up the river.

Tide-table for Hartford.

ean height of water above zero of gauge	2.265 ft.
ean height of high-water above zero of gauge	2.717 ft.
ean height of low-water above zero of gauge	1.813 ft.
ghest water during the observations	3.810 ft.
west water during the observations	1.030 ft.
an rise and fall of tide	.904 ft.
an time of rise of tide	$3^h\ 51^m$
an time of fall of tide	$8^h\ 34^m$
an lunitidal interval	$15^h\ 40^m$
an time of passage of high-water from Saybrook to Hartford	$5^h\ 16^m$
an time of passage of low-water from Saybrook to Hartford	$7^h\ 42^m$
an slope of river	.00000867
tance from Hartford to Saybrook Point	$48\frac{1}{2}$ miles.
ght of mean level at Saybrook Point	.045 ft.
n rise and fall of tide at Saybrook Point	3.490 ft.
n time of rise of tide at Saybrook Point	$6^h\ 17^m$
n time of fall of tide at Saybrook Point	$6^h\ 08^m$
n lunitidal interval at Saybrook Point	$10^h\ 25^m$
erence in time between Hartford and Saybrook	$0^h\ 01^m$

le of corrections, showing the number of minutes to be added to or subtracted from the mean interval of $15^h\ 40^m$ *to obtain the true interval for any day at Hartford.*

our of moon's idian passage.	Correction in minutes.	Notes.
0	+ 3	+ Add to mean interval.
1	− 10	− Subtract from mean interval.
2	− 20	For intermediates between the hours, take proportional parts.
3	− 26	This table is taken from the actual observations.
4	− 30	
5	− 26	
6	− 14	
7	+ 16	
8	+ 28	
9	+ 30	
10	+ 24	
11	+ 14	
12	+ 3	

will be observed from the diagram that the tides are more regular than might be ected at a distance of about 49 miles from the sound. The observations were taken he most favorable season of the year, when there was the least disturbance from n winds and sudden fluctuations in the river. The tidal waves, however, reach rtford, even under the most favorable circumstances, with considerable variation in nt of time and the height of the wave, so that heretofore very little has been known arding their laws.

he quantities given in the foregoing tide-table were obtained in the following nner:

he time of each high and low water was found from the plotted curve, as nearly as sible, and placed in a table; the differences were then taken, from low to high and n high to low water, and arranged in two columns, the means of which were taken the mean time of rise and fall.

s these are the means of 114 tides the probable error is very small.

table was then made of the times of the moon's passage over the meridian and ime of the subsequent high-water at Hartford, corresponding to the first high-water the moon's southing at Saybrook, so that the same tide should be taken at both s. The differences of these times were taken and the mean for the two complete ions of 57 tides was taken for the mean lunitidal interval.

The table of corrections was made by plotting the intervals as ordinates, with th hours of the day as abscissas, and drawing the most probable curve through them The time occupied in the transit of the tidal wave from Sayrbook Point to Hartfor has been computed from the data given in the foregoing table, and is interesting, as i gives the mean time with considerable exactness; and, if a survey of the bed of th river below Hartford is made, it will furnish the means of testing the present formula regarding similar waves of translation in natural channels.

RESISTANCE OF CORDS AND FLOATS.

Some considerable interest having been excited in the question of the resistance o cords and floats when in motion through water, and several experiments having bee tried during the progress of the Connecticut River surveys upon the apparatus use for gauging in order to know what were the actual resistances, such as are deemed o sufficient interest have been added to this report. No reliance was placed upon merely mathematical deductions, owing to the insufficient data existing with regard to the friction and resistance of cords and wires when moved laterally through water or othe fluids.

Experiments were first made upon the longitudinal tension of a cord placed in the current and allowed to sag more or less downstream, with a view to computing the lateral resistance from this element; but direct experiments were afterward made upon the force acting in the direction of the current. The first experiments were made on July 20, 1874, at Hartford between the west abutment and the first pier of the toll bridge. The cord used was .036 of an inch in diameter, of hard-twisted cotton, and o uniform size. This was stretched across from the pier to the abutment, a distance o 27.2 feet, at a depth of 6 inches below the surface. One end was made fast and th other passed over a brass pulley, so as to measure the tension with a spring-balance Four experiments were tried, one of which was rejected, from an evident error in re cording. The others are shown in the following table:

Number of experiment.	Diameter of cord.	Velocity of current.	Greatest versed sine.	Angle at west end.	Tensio on cor
	Inch.	*Feet per sec.*	*Feet.*	° ′	*Ounc*
1	.036	1.51	3.60	30 45	8
2	.036	1.51	3.50	27 30	8
3	.036	1.51	2.50	24 00	12

The velocity of the current was measured with current-meter No. 2, before descri at 6, 13, and 19 feet from the west bank, giving velocities of 1.35, 1.56, and 1.70 per second at these points. The experiments were continued at the bridge of the S mour Paper Company, in Windsor Locks, on July 31 and August 1, with the same s cord and with a larger cord of .192 of an inch diameter. In these experiments ends of the cords were supported by stakes 9.75 feet apart, driven into the bed of canal, so that the current flowed more uniformly and unaffected by the banks bet the points of support than was the case in the former experiments. The cords suspended about 6 inches below the surface, and one end was passed over a pull before. The results of these experiments are shown in the following table:

Number of experiment.	Diameter of cord.	Velocity of current.	Greatest versed sine.	Angle at west end.	Tension cord.
	Inch.	*Foot per sec.*	*Feet.*	° ′	*Ounce*
1	.036	.95	.85	15 10	3
2	.036	.95	1.28	30 20	1
3	.036	.95	1.25	28 30	1¼
4	.036	.95	.69	19 30	2¼
5	.036	.86	.24	6 15	8¾
6	.036	.86	.50	8 00	4¾
7	.036	.86	.75	21 00	2
8	.036	.86	1.10	30 25	1
9	.036	.86	2.21	.. ..	¾
10	.192	.93	.61	19 00	9¾
11	.192	.93	.70	22 30	8
12	.192	.93	.92	29 00	5
13	.192	.93	1.37	36 40	3¾
14	.192	.93	1.97	47 30	2¾

In the foregoing experiments the velocity of the current was measured with current-meter No. 2, before described, at three places across the length of the cord, and the mean velocity deduced therefrom. The meter was placed at the same distance below the surface as the cord and as nearly as practicable under the same conditions; the measurement by the meter occupying some few minutes, while the pressure upon the cord was taken at once. The results of the foregoing experiments not being entirely satisfactory, further experiments were made upon the pressure produced by the direct action of the current upon cords and wires of different sizes on the 17th and 18th of August, at Hartford.

An apparatus for holding the cord and measuring the pressure upon it by means of a scale-beam was constructed as follows: A frame to hold the cord to be tested was made by extending two stout brass wires downward from a horizontal round wooden axis, and bracing them so as to withstand the tension of the cord stretched between their ends. The distance between these arms to which the cord was attached was 4 feet, and the length of the arms was 25 inches.

This frame was hung to a beam by pivots in the ends of the horizontal axis, resting in hook-bearings so as to be easily removed and replaced, and was provided with a horizontal scale-beam having a sliding weight like a steelyard. The whole was balanced, and the wire arms hung vertically when the weight was at zero.

This apparatus was used by lashing the beam across the gunwales of a boat so that the frame would hang on one side with the arms immersed about 9 inches when placed in the proper position for use; the action of the current upon the part of the frame submerged was weighed on the scale-beam. The cord or wire was then attached to the ends of the arms and the pressure again weighed. The difference in weight gave the pressure upon the cord or wire alone.

In these experiments the velocity of the current was measured with current-meter No. 1, from the boat, in the middle of the length occupied by the frame.

Experiments were made upon both cords and wires of the diameters given in the following tables. The cords were all hard-twisted, smooth, and of uniform diameter, and were all of cotton except No. 3, which was a linen fish-line.

Most of the cords were stretched tight between the supports, but some were allowed to sag, as noted in the table. The wires were all nearly straight.

All of the experiments were made at a depth of 9 inches below the surface of the water.

Table showing experiments upon cords.

Number of experiment.	Number of cord.	Diameter in inches.	Length in feet.	Pressure on frame in ounces.	Total pressure in ounces.	Pressure on cord in ounces.	Velocity, feet per second.	Area, square feet.	Coefficient.	Notes.
1	1	.2	4	2.0	8.3	6.3	2.23	.0667	1.189	Cotton cord, 3-inch sag in middle.
2	1	.2	3.92	2.0	8.3	6.3	2.23	.0653	1.214	Cotton cord, 2-inch sag in middle.
3	1	.2	3.92	.6	3.0	2.4	1.28	.0653	1.401	Cotton cord, nearly straight.
4	2	.052	4	2.0	3.9	1.9	2.31	.0173	1.279	Cotton cord, 1-inch sag in middle.
5	2	.052	4	.6	1.1	.5	1.32	.0173	1.030	Cotton cord, nearly straight.
6	3	.045	4	2.0	3.3	1.3	2.27	.0150	1.048	Linen cord, nearly straight.
7	3	.045	4	.6	1.1	.5	1.36	.0150	1.117	Do.
8	4	.038	4	2.0	3.2	1.2	2.23	.0127	1.188	Cotton cord, nearly straight.
9	4	.038	4	2.0	3.3	1.3	2.23	.0127	1.284	Cotton cord, 1-inch sag in middle.
10	4	.038	4	.6	1.1	.5	1.33	.0127	1.379	Cotton cord, nearly straight.
11	4	.038	4	.6	1.0	.4	1.26	.0127	1.238	Cotton cord, 5 feet long, 1 foot 3 inches sag.
12	5	.036	4	2.0	3.2	1.2	2.19	.0120	1.302	Cotton cord, nearly straight.
13	5	.036	4	.6	1.0	.4	1.29	.0120	1.255	Do.
		Mean coefficient							1.225	

The probable error of this mean is ± .021.

Table showing experiments upon wires.

Number of experiment.	Number of wire.	Diameter in inches.	Length in feet.	Pressure on frame in ounces.	Total pressure in ounces.	Pressure on wire in ounces.	Velocity, feet per second.	Area, square feet.	Coefficient.	Notes.
1	1	.075	4	2.0	4.1	2.1	2.20	.0250	1.082	Copper wire, nearly s
2	1	.075	4	.6	1.3	.7	1.19	.0250	1.239	Do.
3	2	.065	4	2.0	3.8	1.8	2.20	.0217	1.066	Do.
4	2	.065	4	.6	1.1	.5	1.22	.0217	.965	Do.
5	3	.032	4	2.0	3.0	1.0	2.19	.0107	1.208	Do.
6	3	.032	4	.6	.8	.2	1.22	.0107	.821	Do.
7	4	.022	4	2.0	2.5	.5	2.18	.0073	.894	Brass wire, nearly str
8	4	.022	4	.6	.8	.2	1.21	.0073	1.128	Do.
9	5	.012	4	2.0	2.3	.3	2.15	.0040	1.028	Do.
10	5	.012	4	.6	.7	.1	1.35	.0040	.824	Do.
	Mean coefficient.....								1.025	

The probable error of this mean is ± .032.

In addition to the foregoing experiments on cords and wires, a few ex were made on the 29th of August, with the same apparatus, upon the resista floats before described in this report, when similarly acted upon by the curre were attached by cords, from 10 to 15 feet long, to the middle of the cord between the arms of the frame as in the foregoing experiments. The floats alone and also the whole system together.

The resistance of the upper float was obtained by attaching it to the ap the manner described, with a weight of 8 ounces hanging to it at a dist inches below, and supporting this weight against the current by an indepen This was also tried without suspending the weight independently.

When both floats were tried together, they were attached independen frame, except in one case, when the upper float alone was attached. The ce lower float was in all cases 18 inches below the surface float. An experi made upon the lower float alone, suspended at the surface by means of the r placed just inside of the top.

The velocity of the current was so small at the time of these experime was very difficult to measure the slight resistance of the surface float. T would have been more satisfactory with a greater velocity. They are, howe in the following table, which shows the deductions made from such expe were tried. These observations were not originally considered sufficiently e be of great value, and consequently were not given in the previous report.

Table showing results of experiments upon floats.

Number of experiment.	Shape of float.	Diameter in inches.	Height in inches.	Pressure on float, in pounds.	Velocity, feet per second.	Submerged area, square feet.	Coefficient.	Notes.
1	Ellipsoid..	6.00	1.50	.0136	1.01	.033	.404	Surface-float by itself, with 8-ou
2	Ellipsoid..	6.00	1.50	.0062	.77	.033	.316	Do
	Mean coefficient.....						.360	

The probable error of this mean is ± .030.

3	Cylinder..	8.47	8.50	.5417	1.28	.500	.662	Subfloat by itself, near the sur
4	Cylinder..	8.47	8.50	.3124	.91	.500	.755	Subfloat 18 inches below surfac attached.
5	Cylinder..	8.47	8.50	.3176	1.07	.500	.555	Subfloat 18 inches below surfa ter only attached.
6	Cylinder..	8.47	8.50	.2719	.87	.500	.719	Subfloat 18 inches below surfac attached.
7	Cylinder..	8.47	8.50	.2541	.86	.500	.687	Do.
	Mean coefficient.....						.676	

The probable error of this mean is ± .023.

In the foregoing tables of the results of experiments upon cords, wires, and floats, the last column contains the coefficient of resistance.

The general formula for the resistance of a body moving in a fluid of unlimited cross-section is—

$$P = C \frac{v^2}{2g} A w$$

in which

P = resistance of the body to motion.
v = velocity.
g = force of gravity at the place.
A = area of cross-section of the body.
w = weight of a unit of volume of the fluid.
C = a coefficient, supposed to be constant for the same form of solid, but varying for different forms.

As, however, for the same fluid the factor $\frac{w}{2g}$ is constant, both numerator and denominator varying proportionally with the small changes in the value of g, it can be omitted in the computation of the coefficient C from a series of observations or experiments in the same fluid. The resulting coefficients are the proper ones for the fluid observed, and if it is desired to apply them to any other they can be placed in the general formula by multiplying by $\frac{2g}{w}$, or making $C = C' \frac{w}{2g}$, C' being the proper coefficient for the general formula. Although it is known that the foregoing formula is not exact for a great range of velocity, it is sufficiently accurate to determine the resistance through a considerable range in the values of the area of the cross-section and velocity if the coefficient is well established by a sufficient number of experiments. It also affords an excellent means of comparing experiments at different velocities and with different areas of cross-section, so as to obtain a mean coefficient. In the foregoing tables the coefficients, which, if applied to the formula, would produce the results of the experiments, have, therefore, been computed by the formula—

$$C = \frac{P}{A v^2}$$

and the means taken of the results. The pressure, P, is taken in pounds, the area, A, in square feet, and the velocity, v, in feet per second.

It will be observed that, in the table of experiments with cords, the coefficients are quite uniform, and there appears to be no material difference between the higher and lower velocities, nor between the larger and smaller cords; neither does there appear to be any difference where the cord has a very considerable curve or sag between the ends.

In the series of experiments upon wires, a greater difference appears in the coefficients. This is owing to the fineness and consequent small areas of some of the wires, and the slowness of the current; and also to the fact that with the apparatus used the pressures could be taken only to the nearest tenth of an ounce; so that the pressures of .1, .2, and .3 were subject to a large percentage of error from this cause. As these errors, however, are equally likely to give too large or too small results, the mean is very near the probable truth.

In the experiments upon the small tin ellipsoids used for surface floats, the results are not quite satisfactory for the same reasons. The two coefficients given do not, however, vary so much as would be expected from the difficulty of measuring so small a resistance. and the mean may be taken as approximately correct. With the cylinders used for subfloats, the coefficients are quite uniform, with the exception of No. 5, in which case the floats were attached to the weighing apparatus by a line to the upper float only; so that there is a possibility that the lower float was carried down stream sufficiently to bring the suspending cord against its top edge and cant it slightly. If the result of this experiment is rejected, it makes the mean coefficient .706, instead of .776, with a probable error of ± .014.

THE MAPS AND DIAGRAMS SHOWN IN THE PLATES.

A map of the river from Hartford to Holyoke has been prepared upon a reduced scale, corresponding to the 6 large sheets of 400 feet to an inch submitted with the first report, and upon it have been placed all the localities and proposed improvements embraced in the previous reports upon this part of the river; so that it shows all that is necessary to comprehend their meaning. The detailed information contained in the larger maps could not be shown upon so small a scale, but all the essential features have been retained.

The principal parts omitted are the lines of soundings across the river each 400 feet, the 10-foot contours above the Hartford base, and some of the minor details that are described in the reports and repeated on the maps. The contour-lines in the bed of the

river are, however, shown, giving the depth below the lowest water. The dotted line outside the ordinary banks of the river shows the limit of overflow in the highest freshets. The characteristic heights of the ground above Hartford base, or low-water mark at that place, have also been placed upon the map in small figures. Enough of these are given to show the general character of the banks and the slope back from the water.

The large figures in the bed of the river on the lines of sections across the valley show the heights of ordinary water and highest water respectively above the low-water plane.

The profile of the river and the diagrams of borings, cross-sections at Thompsonville, and of the heights of water at Hartford, have all been reduced in scale to bring them within suitable limits for the accompanying plates; but it is believed that they show every important feature of the original sheets. The diagram of sections at Thompsonville shows all the sections across the river upon which float or meter observations were taken. At positions F and G on the map, 7 parallel lines were run across the river at 50 feet distance apart. They are numbered in the following order, commencing with the one highest up the river: 7, 6, 1, 2, 3, 4, 5. The lines 1, 2, 3, 4, 5, embraced the 200 feet called position F, and the lines 7, 6, 1, 2, 3, embraced the 200 feet called position G. The meter-observations were taken on the middle lines 1 and 3 of these positions. On the large sheet before submitted, the several lines were shown in different colors; but on the present plate they are necessarily all in black, and are shown by the different character of the lines. The 3 sheets showing the apparatus used in gauging, the diagram of vertical curves of current velocities, and the diagrams showing the relative heights and discharges at Thompsonville, remain the same as before presented, with the requisite changes for adapting them to be printed.

Two new diagrams have been added in the present plates to bring the report up to date, viz: another diagram of the heights of water at Hartford for the year 1875, and a sheet showing the tides at Hartford for two complete lunations in August, September and October of 1874.

All of which is respectfully submitted.

THEO. G. ELLIS,
Civil Engineer.

LIST OF PLATES.

I. Connecticut River, from Hartford to Windsor Locks.
II. Connecticut River, from Windsor Locks to Long Meadow.
III. Connecticut River, from Long Meadow to Holyoke.
IV. Diagram of borings in the bed of the river.
V. Profile of Connecticut River from Hartford to Holyoke.
VI. Diagrams showing cross-sections of the river and mean vertical curves of current velocities at Thompsonville.
VII. Apparatus used in gauging.
VIII. Diagram showing the height of the river at Hartford from February 1 to December 31, 1871.
IX. Diagram showing the height of the river at Hartford from January 1 to December 31, 1872.
X. Diagram showing the height of the river at Hartford from January 1 to December 31, 1873.
XI. Diagram showing the height of the river at Hartford from January 1 to December 31, 1874.
XII. Diagram showing the height of the river at Hartford from January 1 to December 31, 1875.
XIII. Diagram showing heights and discharges of the Connecticut River at Thompsonville.
XIV. Diagram showing tides at Hartford in 1874.
XV. Diagram showing the height of the river at Hartford from January 1 to December 31, 1876.
XVI. Diagram showing the height of the river at Hartford from January 1 to December 31, 1877.

ADDENDA.

Since the foregoing report was submitted the observations of the height of the water at Hartford have been continued.

At the times of high-water in 1876 and 1877 a comparison was made of the heights as shown upon the old gauge at the toll-bridge and upon the new gauge which was established on the steamboat-wharf at the foot of State street. The slope of the surface between these two points was found to be considerable at the time of freshets, so that the readings upon the new gauge were less than upon the old, although they were practically the same at the low stages, the zeroes of the two gauges being at the same level. In order, therefore, to obtain the most correct approximate discharge from the gauge-readings, a new table of discharge for the heights upon the new gauge

been computed, and the corrected quantities entered in the tables of discharge for years 1876 and 1877.

his new table of discharge differs but little, however, from that heretofore given, ept at the higher stages, when the slope of the surface is the greatest.

he tables of mean daily heights of water and daily discharge for the years 1876 and have been computed, together with the totals for the years.

ables have also been prepared showing the number of days in each month the rage for the day was above a given height, corresponding to the tables heretofore uded in the report for the previous years.

ll of the before-mentioned tables and diagrams showing the observed heights of ter at Hartford for the years 1876 and 1877 are appended herewith.

charge of the Connecticut River at Hartford, for each foot in height, by the United States gauge at the foot of State street.

ight.	Discharge per second.	Height.	Discharge per second.	Height.	Discharge per second.	Height.	Discharge per second.
Feet.	*Cubic feet.*	*Feet.*	*Cubic feet.*	*Feet.*	*Cubic feet.*	*Feet.*	*Cubic feet.*
0	5,000	8	27,400	16	72,700	24	142,400
1	5,500	9	32,400	17	79,600	25	153,400
2	6,600	10	37,500	18	87,100	26	164,800
3	8,500	11	42,900	19	95,200	27	176,200
4	11,100	12	48,500	20	103,700	28	187,600
5	14,500	13	54,200	21	112,700	29	199,200
6	18,400	14	60,100	22	122,100	30	211,000
7	22,700	15	66,200	23	132,000		

Table showing the daily discharge and height of the Connecticut River at Hartford fro uary 1 to December 31, 1876.

Date.	Height, feet.	Millions of cubic feet.	Date.	Height, feet.	Millions of cubic feet.	Date.	Height, feet.	Mil cub
1876.			1876.			1876.		
Jan. 1	6.52	1,780	Mar. 1	4.93	1,230	May 1	14.30	
2	7.35	2,100	2	4.46	1,086	2	14.37	
3	8.58	2,614	3	3.87	925	3	13.49	
4	8.63	2,636	4	4.13	994	4	12.74	
5	9.17	2,874	5	4.05	972	5	11.72	
6	7.77	2,270	6	3.98	954	6	11.33	
7	6.67	1,835	7	4.73	1,168	7	12.07	
8	6.33	1,709	8	7.70	2,242	8	13.70	
9	6.18	1,653	9	11.50	3,946	9	15.43	
10	6.23	1,671	10	13.97	5,179	10	16.62	
11	6.06	1,610	11	15.13	5,794	11	17.37	
12	6.55	1,790	12	12.70	4,535	12	18.12	
13	8.98	2,790	13	10.83	3,629	13	18.98	
14	9.35	2,950	14	9.55	3,040	14	19.20	
15	8.60	2,623	15	8.70	2,667	15	18.96	
16	8.45	2,560	16	7.97	2,354	16	18.13	
17	7.93	2,336	17	7.27	2,067	17	16.73	
18	7.53	2,172	18	5.97	1,578	18	14.85	
19	7.10	2,000	19	5.38	1,276	19	13.24	
20	7.96	2,350	20	5.57	1,441	20	12.03	
21	9.10	2,842	21	7.27	2,067	21	11.35	
22	10.49	3,469	22	7.40	2,120	22	10.97	
23	11.70	4,044	23	7.53	2,173	23	11.45	
24	11.62	4,005	24	7.15	2,020	24	11.74	
25	10.88	3,652	25	7.10	2,000	25	11.51	
26	10.07	3,273	26	12.07	4,225	26	11.11	
27	9.33	2,944	27	15.63	6,075	27	10.55	
28	9.20	2,886	28	15.33	5,905	28	9.60	
29	9.03	2,812	29	15.03	5,735	29	8.68	
30	8.90	2,754	30	17.95	7,494	30	7.75	
31	9.35	2,952	31	17.15	6,975	31	7.30	
		70,956			93,866			
Feb. 1	9.81	3,155	Apr. 1	15.10	5,776	June 1	6.97	
2	10.09	3,282	2	12.83	4,599	2	6.67	
3	9.59	3,057	3	10.48	3,464	3	6.15	
4	8.63	2,636	4	10.90	3,661	4	6.05	
5	7.67	2,230	5	13.07	4,718	5	6.05	
6	7.50	2,160	6	12.39	4,383	6	7.72	
7	7.37	2,106	7	11.03	3,722	7	8.24	
8	8.75	2,688	8	10.73	3,581	8	7.25	
9	9.46	3,000	9	10.83	3,629	9	6.44	
10	9.57	3,050	10	10.08	3,377	10	5.70	
11	9.35	2,952	11	9.38	2,965	11	5.06	
12	8.83	2,723	12	9.59	3,057	12	5.05	
13	9.30	2,930	13	11.32	3,860	13	5.27	
14	9.20	2,886	14	13.39	4,880	14	5.00	
15	10.08	3,278	15	17.20	7,005	15	4.97	
16	10.42	3,435	16	20.48	9,333	16	4.70	
17	8.36	2,520	17	21.81	10,395	17	4.69	
18	6.90	1,923	18	21.45	10,110	18	4.78	
19	6.56	1,794	19	19.05	8,261	19	4.62	
20	5.80	1,520	20	16.38	6,508	20	4.25	
21	5.10	1,285	21	14.18	5,286	21	4.45	
22	5.03	1,262	22	13.88	5,132	22	4.50	
23	4.32	990	23	14.28	5,339	23	4.78	
24	4.80	1,190	24	14.62	5,518	24	4.99	
25	5.50	1,417	25	14.96	5,698	25	4.89	
26	5.32	1,327	26	14.89	5,660	26	4.59	
27	5.00	1,252	27	14.55	5,480	27	4.27	
28	4.83	1,200	28	13.89	5,137	28	4.15	
29	5.00	1,152	29	13.78	5,080	29	3.99	
			30	13.90	5,142	30	3.92	
		64,400			160,756			

Table showing the daily discharge and height of the Connecticut River, &c.—Continued.

Date.	Height, feet.	Millions of cubic feet.	Date.	Height, feet.	Millions of cubic feet.	Date.	Height, feet.	Millions of cubic feet.
1876.			1876.			1876.		
July 1	3.97	950	Sept. 1	1.43	510	Nov. 1	2.00	570
2	3.85	920	2	1.20	490	2	2.38	622
3	3.70	885	3	1.18	489	3	2.47	635
4	3.55	848	4	0.97	474	4	1.98	568
5	3.43	820	5	0.98	475	5	1.67	532
6	3.35	803	6	1.14	486	6	1.85	552
7	3.27	785	7	1.62	528	7	2.20	595
8	3.20	770	8	2.15	589	8	2.23	600
9	2.84	696	9	1.85	552	9	2.15	590
10	2.34	615	10	1.85	552	10	2.35	616
11	2.82	692	11	1.80	547	11	2.60	655
12	3.01	728	12	1.59	524	12	2.62	659
13	3.07	742	13	1.46	512	13	2.63	661
14	3.03	732	14	1.63	529	14	2.25	603
15	2.91	709	15	1.92	560	15	2.33	614
16	2.50	640	16	2.23	600	16	2.25	780
17	2.26	604	17	2.04	575	17	2.95	715
18	2.37	620	18	2.82	693	18	3.00	725
19	2.45	632	19	2.55	647	19	3.17	762
20	2.68	670	20	2.70	672	20	3.22	774
21	2.48	634	21	2.86	700	21	3.32	796
22	2.77	685	22	2.91	709	22	4.07	977
23	2.64	662	23	2.58	652	23	4.17	1,005
24	2.69	670	24	2.33	614	24	3.62	865
25	2.99	725	25	2.33	614	25	3.63	866
26	2.89	705	26	2.42	628	26	3.47	830
27	2.60	655	27	2.07	579	27	3.03	732
28	2.41	626	28	1.35	502	28	2.68	670
29	2.10	582	29	2.00	570	29	2.38	621
30	1.93	561	30	2.33	614	30	2.45	632
31	2.57	650						
		22,016			17,186			20,822
Aug. 1	2.55	647	Oct. 1	2.20	596	Dec. 1	2.27	606
2	2.38	621	2	2.15	589	2	2.08	575
3	2.37	620	3	2.38	622	3	1.78	545
4	2.20	595	4	2.53	644	4	1.73	539
5	2.22	599	5	2.13	587	5	1.88	556
6	1.95	565	6	2.37	620	6	2.20	595
7	1.84	551	7	1.92	560	7	1.92	560
8	1.84	551	8	1.60	525	8	1.92	560
9	1.78	545	9	1.47	513	9	2.70	672
10	1.88	556	10	1.75	541	10	0.95	473
11	1.76	542	11	1.40	507	11	1.37	504
12	1.79	549	12	1.30	498	12	2.68	669
13	1.31	499	13	1.48	514	13	2.02	572
14	1.11	483	14	2.07	579	14	1.77	543
15	1.28	496	15	1.68	534	15	2.02	572
16	1.37	504	16	1.07	481	16	1.72	538
17	1.74	540	17	0.75	461	17	0.83	466
18	1.88	556	18	1.37	504	18	1.27	495
19	2.05	576	19	1.70	536	19	1.20	490
20	1.72	538	20	1.63	529	20	0.88	469
21	1.35	502	21	1.92	560	21	1.18	489
22	1.53	519	22	1.93	561	22	1.37	504
23	1.88	555	23	1.95	564	23	2.05	576
24	1.83	550	24	1.97	566	24	1.75	541
25	1.62	528	25	1.78	545	25	1.52	518
26	1.25	494	26	1.45	511	26	1.87	555
27	0.74	461	27	1.25	494	27	2.15	589
28	0.75	462	28	1.67	523	28	2.12	585
29	0.96	473	29	1.70	535	29	2.43	630
30	1.24	494	30	1.80	542	30	2.65	665
31	1.36	503	31	2.15	589	31	1.38	505
		16,674			16,930			17,156

Totals for the months and year.

1876.	Cubic feet.	1876.	
January	79, 956, 000, 000	August	
February	64, 400, 000, 000	September	
March	93, 866, 000, 000	October	
April	160, 756, 000, 000	November	
May	155, 521, 000, 000	December	
June	41, 008, 000, 000		
July	22, 016, 000, 000	Total	7

Table showing the number of days in 1876 *that the average for the day at Hartfo a given height.*

Height.	No. of days.	Height.	No. of days.	Height.	No. of days.	Heig
JANUARY.		6 feet and over..	21	20 feet and over..	3	8 feet and
		7 feet and over..	21	21 feet and over..	2	
1 foot and over ..	31	8 feet and over..	13			JULY
2 feet and over ..	31	9 feet and over..	12	MAY.		
3 feet and over...	31	10 feet and over..	11			1 foot and
4 feet and over...	31	11 feet and over..	10	1 foot and over..	31	2 feet and
5 feet and over ..	31	12 feet and over..	9	2 feet and over..	31	3 feet and
6 feet and over...	31	13 feet and over..	7	3 feet and over..	31	
7 feet and over...	24	14 feet and over..	6	4 feet and over..	31	AUGU
8 feet and over ..	18	15 feet and over..	6	5 feet and over..	31	
9 feet and over...	12	16 feet and over..	2	6 feet and over..	31	1 foot and
10 feet and over...	5	17 feet and over..	2	7 feet and over..	31	2 feet and
11 feet and over ..	2			8 feet and over..	29	
		APRIL.		9 feet and over..	28	SEPTEM
FEBRUARY.				10 feet and over..	27	
		1 foot and over..	30	11 feet and over..	25	1 foot and
1 foot and over...	29	2 feet and over..	30	12 feet and over..	18	2 feet and
2 feet and over...	29	3 feet and over..	30	13 feet and over..	15	
3 feet and over ..	29	4 feet and over..	30	14 feet and over..	12	OCTOB
4 feet and over...	29	5 feet and over..	30	15 feet and over..	9	
5 feet and over...	26	6 feet and over..	30	16 feet and over .	8	1 foot and
6 feet and over...	19	7 feet and over..	30	17 feet and over..	6	2 feet and
7 feet and over..	17	8 feet and over..	30	18 feet and over..	5	
8 feet and over ..	14	9 feet and over..	30	19 feet and over..	1	NOVEM
9 feet and over	10	10 feet and over..	28			
10 feet and over ..	3	11 feet and over..	23	JUNE.		1 foot and
		12 feet and over..	21			2 feet and
MARCH.		13 feet and over..	19	1 foot and over..	30	3 feet and
		14 feet and over..	13	2 feet and over..	30	4 feet and
1 foot and over...	31	15 feet and over..	7	3 feet and over..	30	
2 feet and over...	31	16 feet and over..	6	4 feet and over..	28	DECEM
3 feet and over ..	31	17 feet and over..	5	5 feet and over..	14	
4 feet and over ..	29	18 feet and over..	4	6 feet and over..	9	1 foot and
5 feet and over...	24	19 feet and over..	4	7 feet and over..	3	2 feet and

Totals for the year from January 1 *to December* 31, 1876.

Total for twelve months.		Total for twelve months.		Total for twelve months.		Total for t
Height.	No. of days.	Height.	No. of days.	Height.	No. of days.	Heig
1 foot and over...	357	7 feet and over..	126	12 feet and over..	48	17 feet an
2 feet and over .	280	8 feet and over..	105	13 feet and over	41	18 feet an
3 feet and over ..	204	9 feet and over..	92	14 feet and over.	31	19 feet an
4 feet and over...	180	10 feet and over..	74	15 feet and over..	22	20 feet an
5 feet and over...	156	11 feet and over..	60	16 feet and over..	16	21 feet an
6 feet and over...	141					

le showing the daily discharge and height of the Connecticut River at Hartford from January 1 to December 31, 1877.

Date.	Height, feet.	Millions of cubic feet.	Date.	Height, feet.	Millions of cubic feet.	Date.	Height, feet.	Millions of cubic feet.
7.			1877.			1877.		
1	1.30	498	Mar. 1	2.87	702	May 1	9.88	3,187
2	2.13	586	2	3.07	741	2	9.44	2,991
3	1.72	539	3	5.33	1,359	3	8.93	2,767
4	1.15	486	4	5.71	1,490	4	8.42	2,545
5	1.18	489	5	5.86	1,540	5	7.78	2,275
6	1.65	481	6	5.68	1,480	6	7.25	2,060
7	2.78	685	7	5.33	1,359	7	6.60	1,810
8	1.97	566	8	4.84	1,210	8	6.02	1,595
9	1.93	561	9	6.63	1,820	9	5.55	1,434
0	2.30	610	10	11.02	3,718	10	5.27	1,340
1	2.15	589	11	12.83	4,599	11	5.08	1,278
2	1.95	564	12	12.33	4,353	12	4.98	1,245
3	2.18	593	13	11.25	3,826	13	4.76	1,176
4	1.73	540	14	9.59	3,057	14	4.45	1,084
5	1.68	534	15	7.98	2,358	15	4.19	1,010
6	2.30	610	16	6.82	1,892	16	4.14	995
7	2.05	575	17	6.24	1,675	17	4.19	1,010
8	1.95	564	18	5.46	1,404	18	4.32	1,045
9	1.87	555	19	5.23	1,326	19	4.36	1,056
0	2.20	595	20	5.06	1,269	20	4.76	1,176
1	1.73	540	21	4.55	1,113	21	4.65	1,145
2	1.87	555	22	4.88	1,214	22	4.58	1,121
3	2.08	580	23	5.51	1,420	23	4.60	1,128
4	2.02	572	24	6.21	1,665	24	4.78	1,183
5	1.65	531	25	6.73	1,857	25	4.96	1,240
6	1.72	539	26	7.54	2,175	26	5.64	1,465
7	2.10	582	27	12.68	4,525	27	5.27	1,340
8	2.10	582	28	18.82	7,097	28	4.44	1,080
9	2.20	595	29	22.12	10,695	29	3.97	925
0	2.32	612	30	22.57	11,080	30	3.61	863
1	2.17	592	31	20.32	9,234	31	3.36	805
		17,500			93,253			45,374
	2.32	612	Apr. 1	17.13	6,962	June 1	3.12	751
	2.42	628	2	14.55	5,480	2	2.76	683
	2.67	667	3	13.14	4,753	3	2.32	613
	2.65	665	4	12.63	4,500	4	2.33	615
	2.72	675	5	11.95	4,165	5	2.37	620
	2.93	712	6	11.44	3,918	6	2.40	625
7	2.65	665	7	10.98	3,700	7	2.45	632
8	2.82	692	8	10.73	3,581	8	3.73	805
9	2.90	708	9	10.47	3,459	9	3.80	908
0	2.78	685	10	10.09	3,283	10	3.88	930
1	2.58	652	11	9.77	3,135	11	3.73	891
2	2.65	665	12	9.92	3,205	12	3.65	873
3	2.42	628	13	9.81	3,155	13	3.57	853
4	2.27	605	14	9.26	2,912	14	3.40	814
15	2.42	628	15	8.58	2,615	15	3.35	802
16	2.45	632	16	8.34	2,510	16	3.35	802
17	2.63	661	17	8.13	2,420	17	2.87	701
18	1.88	556	18	8.10	2,408	18	2.37	620
19	2.02	572	19	8.43	2,550	19	2.76	682
20	2.38	615	20	9.54	3,045	20	2.43	629
21	2.35	618	21	12.11	4,245	21	2.32	611
22	2.53	645	22	13.39	4,880	22	2.07	579
23	2.62	660	23	12.87	4,617	23	2.02	572
24	2.97	720	24	11.82	4,100	24	2.01	570
25	3.23	775	25	11.18	3,793	25	2.32	612
26	2.85	698	26	10.79	3,610	26	2.26	605
27	2.98	722	27	10.60	3,520	27	2.46	633
28	3.02	730	28	10.26	3,360	28	2.35	617
			29	9.87	3,183	29	2.36	618
			30	9.87	3,183	30	2.51	641
		18,491			110,247			20,907

Table showing the daily discharge and height of the Connecticut River, &c.—Continu

Date.	Height. feet.	Millions of cubic feet.	Date.	Height, feet.	Millions of cubic feet.	Date.	Height, feet.	Milli cubi
1877.			1877.			1877.		
July 1	2.40	625	Sept. 1	3.21	772	Nov. 1	4.18	
2	2.09	582	2	2.84	696	2	4.55	
3	5.02	1,259	3	2.74	680	3	5.35	
4	6.18	1,727	4	2.46	634	4	8.96	
5	5.12	1,290	5	2.68	669	5	8.99	
6	5.26	1,337	6	2.68	669	6	9.20	
7	4.45	1,085	7	2.68	669	7	10.27	
8	3.82	913	8	3.01	728	8	9.47	
9	3.46	828	9	2.91	709	9	9.52	
10	3.48	832	10	2.96	718	10	13.01	
11	4.05	966	11	2.87	702	11	14.13	
12	4.43	1,077	12	2.57	650	12	12.80	
13	4.01	962	13	2.29	609	13	11.20	
14	3.59	858	14	1.95	564	14	9.92	
15	3.12	751	15	1.87	555	15	8.25	
16	2.71	673	16	1.68	534	16	7.17	
17	2.48	637	17	1.76	542	17	6.65	
18	2.04	575	18	1.65	530	18	6.61	
19	2.23	600	19	1.68	534	19	6.23	
20	2.57	650	20	1.82	529	20	6.48	
21	2.76	683	21	1.70	536	21	6.44	
22	2.62	659	22	1.21	492	22	6.20	
23	3.10	748	23	1.46	512	23	6.75	
24	2.82	693	24	1.67	533	24	5.58	
25	2.62	660	25	2.09	581	25	5.72	
26	2.62	660	26	1.77	543	26	8.13	
27	2.54	647	27	1.76	542	27	9.30	
28	2.43	630	28	1.90	556	28	9.05	
29	2.23	605	29	1.87	555	29	8.50	
30	2.40	625	30	1.68	534	30	8.14	
31	2.49	638						
		25,475			18,089			
Aug. 1	3.59	858	Oct. 1	1.32	500	Dec. 1	7.73	
2	4.79	1,185	2	1.15	486	2	7.14	
3	4.09	983	3	1.93	562	3	6.38	
4	3.21	771	4	2.21	596	4	6.12	
5	2.68	670	5	2.43	629	5	6.00	
6	2.43	630	6	3.38	809	6	5.99	
7	2.56	649	7	3.68	880	7	6.19	
8	2.57	650	8	3.44	823	8	6.60	
9	2.54	646	9	3.93	940	9	8.42	
10	2.66	665	10	3.52	841	10	9.91	
11	2.68	669	11	4.29	1,038	11	9.08	
12	2.48	637	12	4.21	1,015	12	7.72	
13	2.73	677	13	3.52	840	13	6.60	
14	2.87	701	14	3.91	935	14	5.88	
15	2.68	669	15	4.21	1,015	15	5.33	
16	2.43	630	16	4.24	1,024	16	4.83	
17	2.18	593	17	3.99	955	17	4.67	
18	2.35	617	18	3.54	822	18	4.69	
19	2.37	620	19	3.71	886	19	4.98	
20	2.49	639	20	3.93	940	20	4.65	
21	2.62	660	21	4.57	1,019	21	4.53	
22	2.99	723	22	5.94	1,566	22	4.47	
23	2.68	670	23	6.79	1,880	23	4.32	
24	2.65	664	24	6.77	1,874	24	4.40	
25	2.40	625	25	6.02	1,595	25	4.19	
26	2.43	630	26	5.35	1,365	26	4.06	
27	2.29	609	27	4.96	1,240	27	3.90	
28	2.48	637	28	4.82	1,196	28	3.63	
29	3.36	805	29	5.02	1,259	29	3.63	
30	3.84	918	30	4.79	1,185	30	3.70	
31	3.54	846	31	4.36	1,057	31	3.47	
		22,946			31,772			

Totals for the months and year.

1877.	Cubic feet.	1877.	Cubic feet.
January	17, 500, 000, 000	August	22, 946, 000, 000
February	18, 491, 000, 000	September	18, 089, 000, 000
March	93, 253, 000, 000	October	31, 772, 000, 000
April	110, 247, 000, 000	November	75, 825, 000, 000
May	45, 374, 000, 000	December	46, 382, 000, 000
June	20, 907, 000, 000		
July	25, 475, 000, 000	Total	526, 261, 000, 000

Table showing the number of days in 1877 *that the average for the day at Hartford was above a given height.*

Height.	No. of days.	Height.	No. of days.	Height.	No. of days.	Height.	No. of days.
JANUARY.		21 feet and over..	2	9 feet and over...	2	2 feet and over..	28
		22 feet and over..	2			3 feet and over..	26
1 foot and over...	31			JUNE.		4 feet and over..	15
2 feet and over...	15	APRIL.				5 feet and over..	6
				1 foot and over...	30	6 feet and over..	3
FEBRUARY.		1 foot and over..	30	2 feet and over...	30		
		2 feet and over..	30	3 feet and over...	10	NOVEMBER.	
1 foot and over...	28	3 feet and over..	30				
2 feet and over...	27	4 feet and over..	30	JULY.		1 foot and over..	30
3 feet and over...	2	5 feet and over..	30			2 feet and over..	30
		6 feet and over..	30	1 foot and over...	31	3 feet and over..	30
MARCH.		7 feet and over..	30	2 feet and over...	31	4 feet and over..	30
		8 feet and over..	30	3 feet and over...	14	5 feet and over..	28
1 foot and over...	31	9 feet and over..	25	4 feet and over...	8	6 feet and over..	25
2 feet and over...	31	10 feet and over..	18	5 feet and over...	4	7 feet and over..	18
3 feet and over...	30	11 feet and over..	11	6 feet and over...	1	8 feet and over..	17
4 feet and over...	29	12 feet and over..	7			9 feet and over..	11
5 feet and over...	26	13 feet and over..	4	AUGUST.		10 feet and over..	5
6 feet and over...	17	14 feet and over..	2			11 feet and over..	4
7 feet and over...	12	15 feet and over..	1	1 foot and over...	31	12 feet and over..	3
8 feet and over...	10	16 feet and over..	1	2 feet and over...	31	13 feet and over..	2
9 feet and over...	10	17 feet and over..	1	3 feet and over...	7	14 feet and over..	1
10 feet and over...	9			4 feet and over...	2		
11 feet and over...	9	MAY.				DECEMBER.	
12 feet and over...	7			SEPTEMBER.		1 foot and over..	31
13 feet and over...	4	1 foot and over..	31			2 feet and over..	31
14 feet and over...	4	2 feet and over..	31	1 foot and over...	30	3 feet and over..	31
15 feet and over...	4	3 feet and over..	31	2 feet and over...	14	4 feet and over..	26
16 feet and over...	4	4 feet and over..	28	3 feet and over...	2	5 feet and over..	15
17 feet and over...	4	5 feet and over..	13			6 feet and over..	12
18 feet and over...	4	6 feet and over..	8	OCTOBER.		7 feet and over..	6
19 feet and over...	3	7 feet and over .	6			8 feet and over..	3
20 feet and over...	3	8 feet and over..	4	1 foot and over...	31	9 feet and over..	2

Totals for the year from January 1 *to December* 31, 1877.

Total for twelve months.		Total for twelve months.		Total for twelve months.		Total for twelve months.	
Height.	No. of days.	Height.	No. of days.	Height.	No. of days.	Height.	No. of days.
1 foot and over.	365	7 feet and over..	72	13 feet and over .	10	18 feet and over..	4
2 feet and over..	329	8 feet and over..	64	14 feet and over..	7	19 feet and over..	3
3 feet and over..	213	9 feet and over .	50	15 feet and over..	5	20 feet and over..	3
4 feet and over..	168	10 feet and over..	32	16 feet and over..	5	21 feet and over..	2
5 feet and over..	122	11 feet and over..	24	17 feet and over..	5	22 feet and over..	2
6 feet and over..	96	12 feet and over..	17				

Plate I.

Plate II.

Plate III

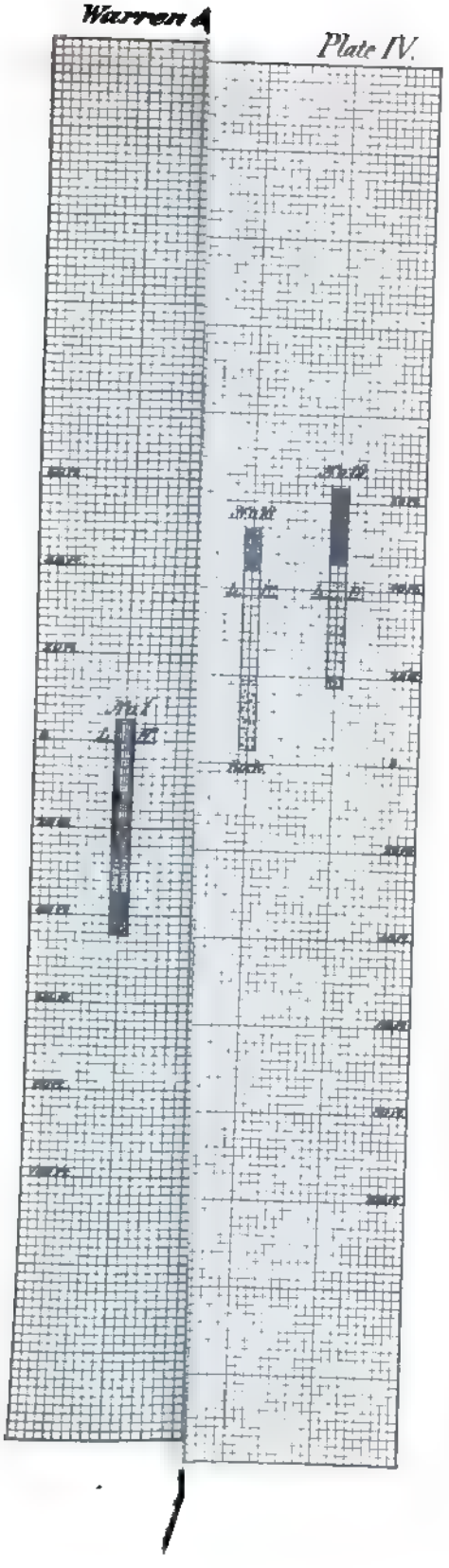

Warren A
Plate IV.

Plate VI.

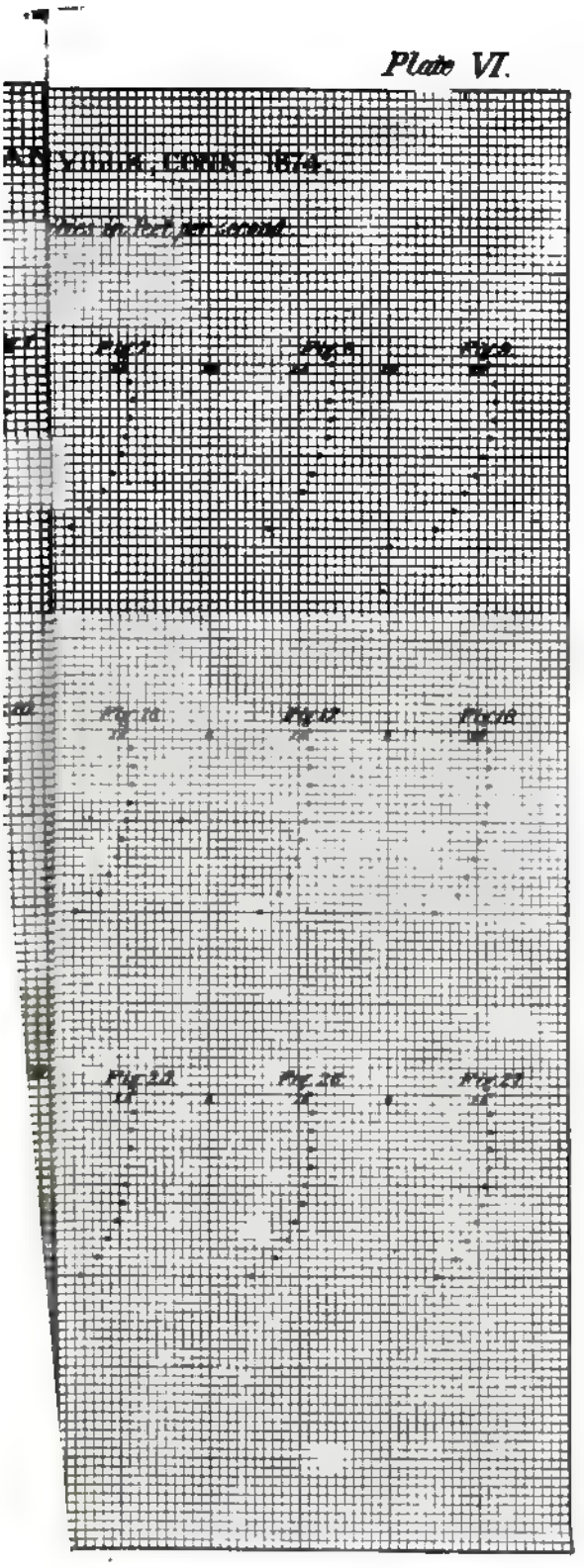

CONN. 1874.
in feet per second.
Fig. 7
Fig. 8
Fig. 9
Fig. 16
Fig. 17
Fig. 18
Fig. 22
Fig. 26
Fig. 27

Plate VII.

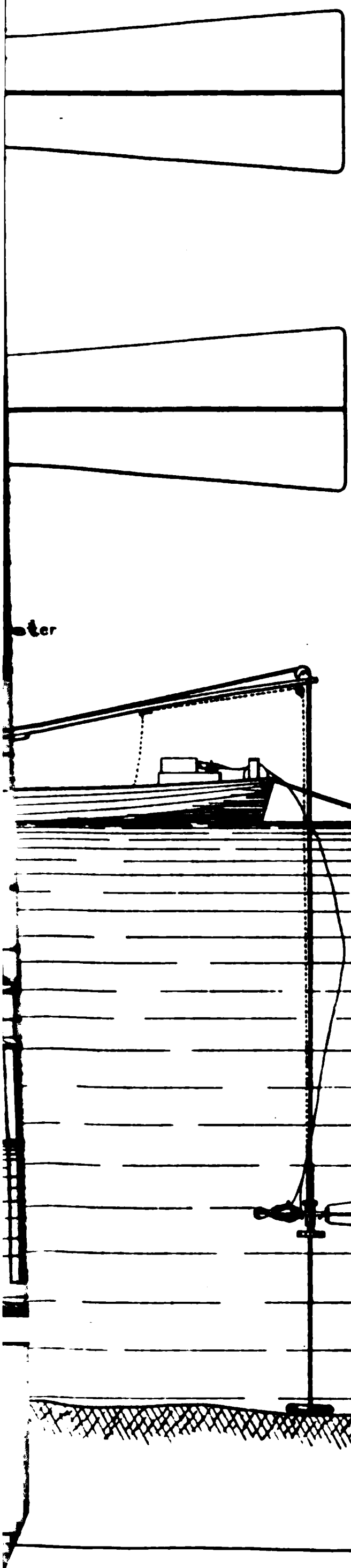


Plate VIII.

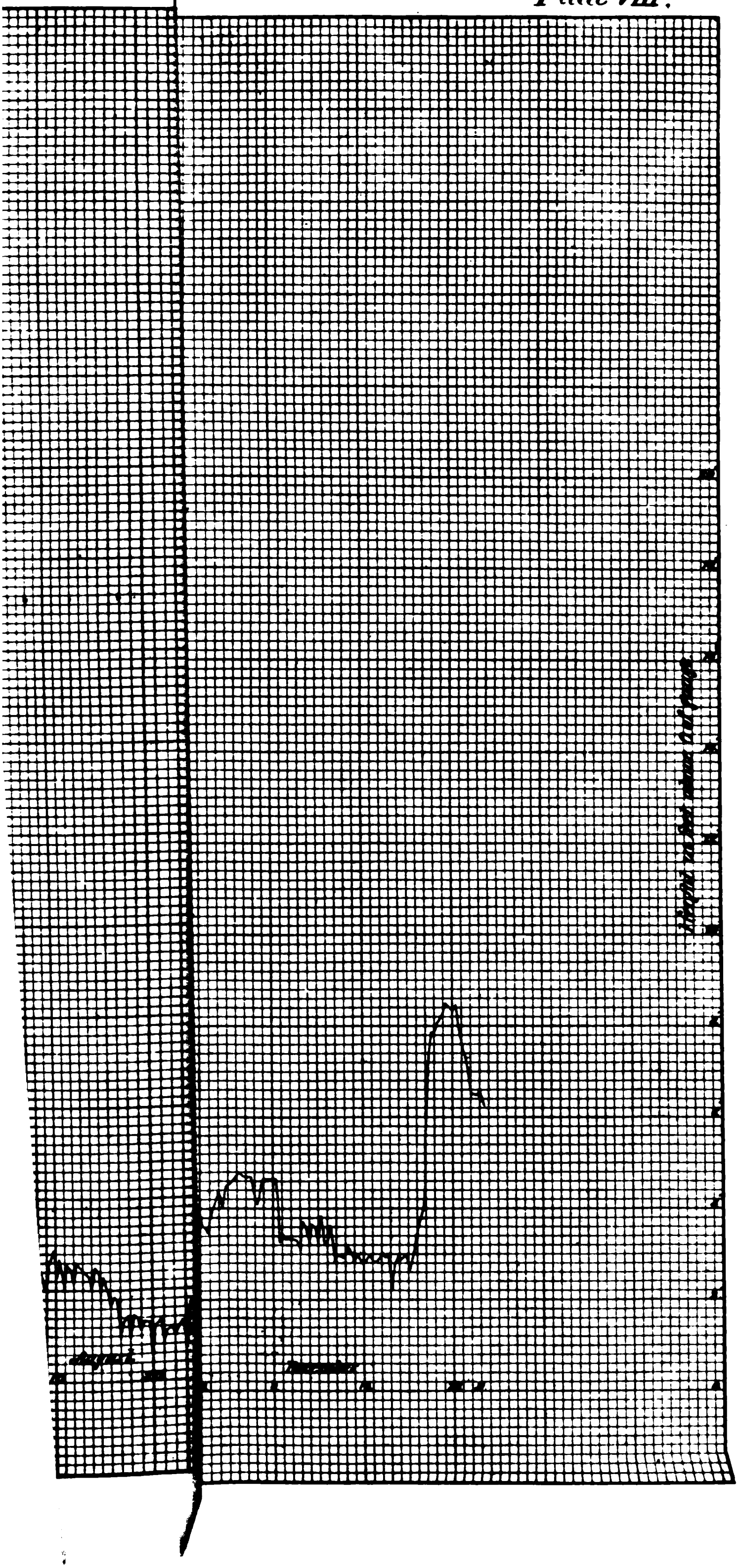


Plate IX.

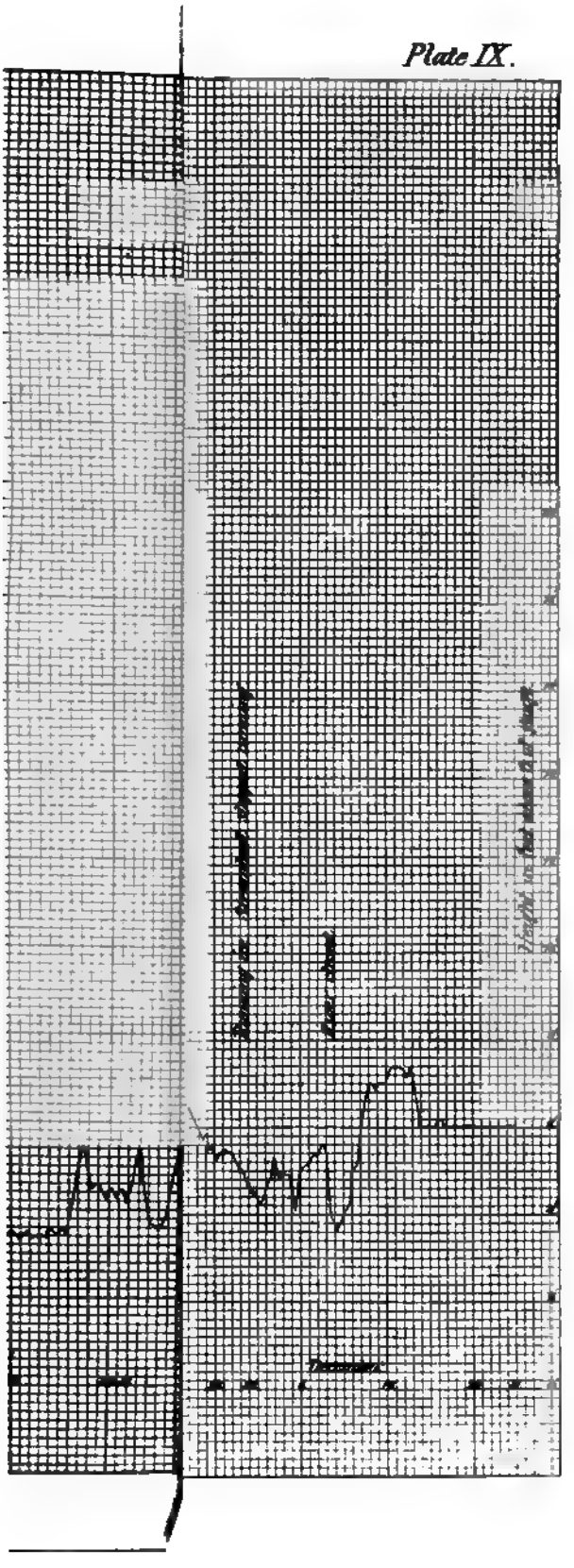


Plate X.

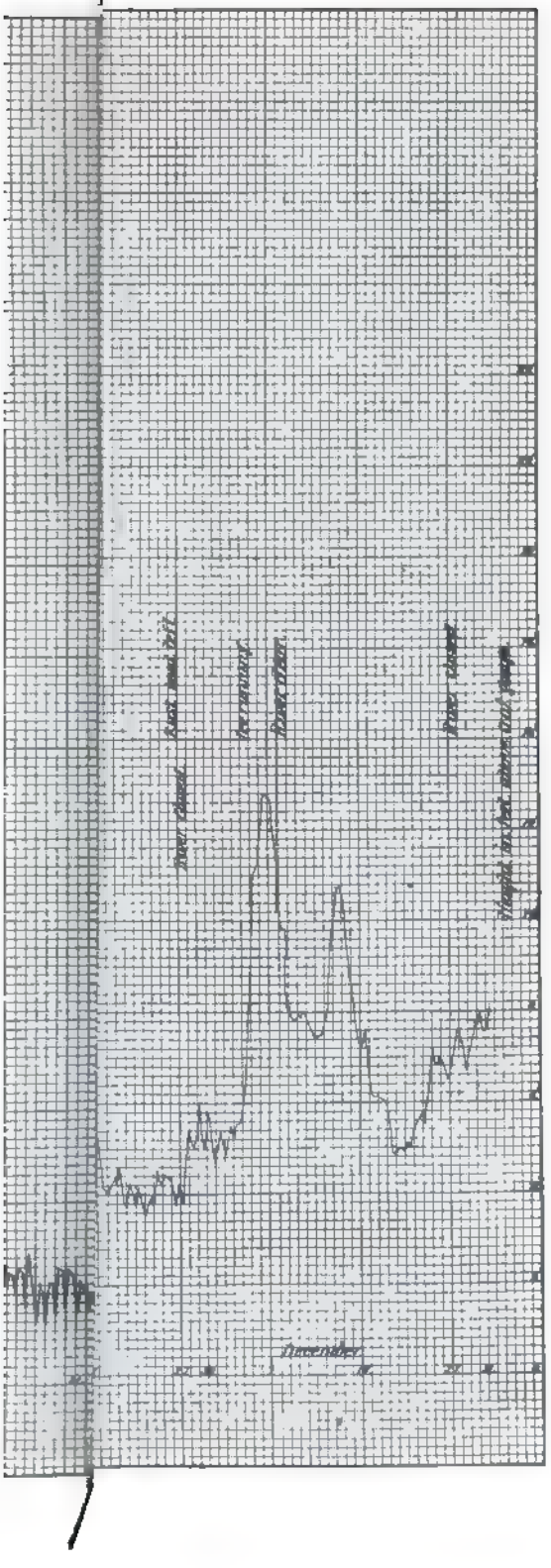
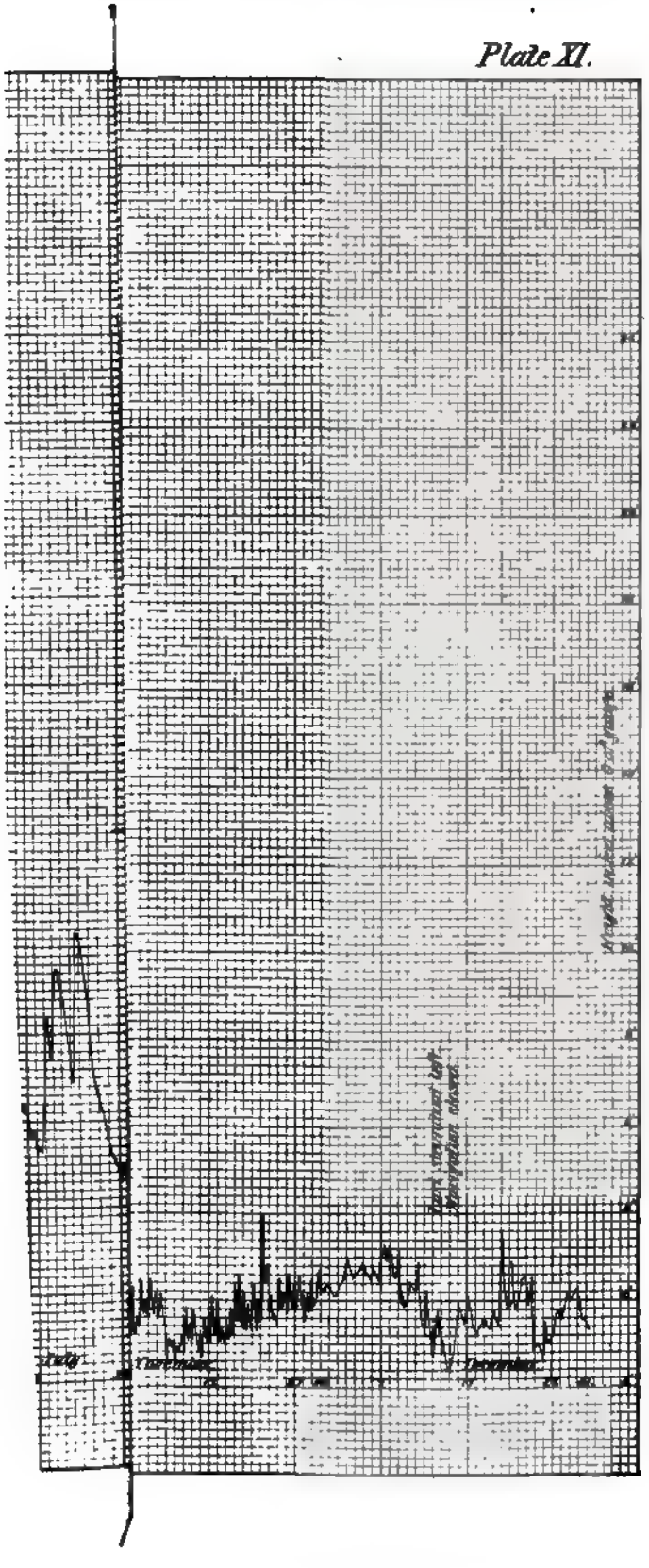
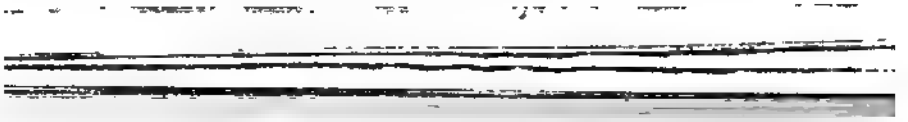


Plate XI.





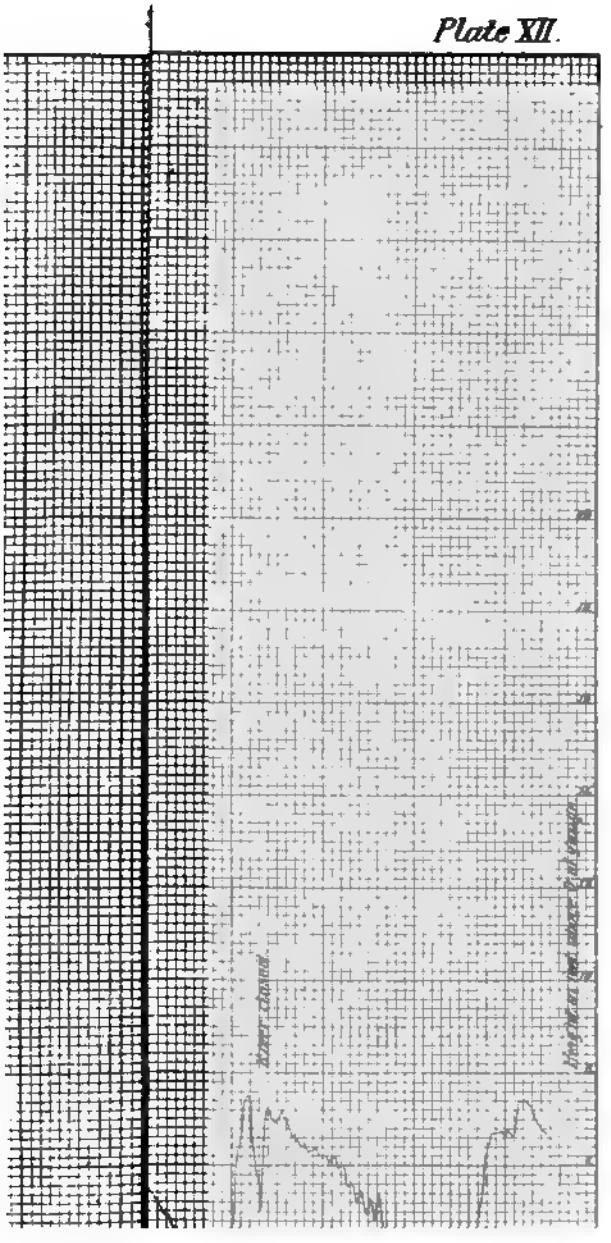


Plate XII.

Plate XIII.

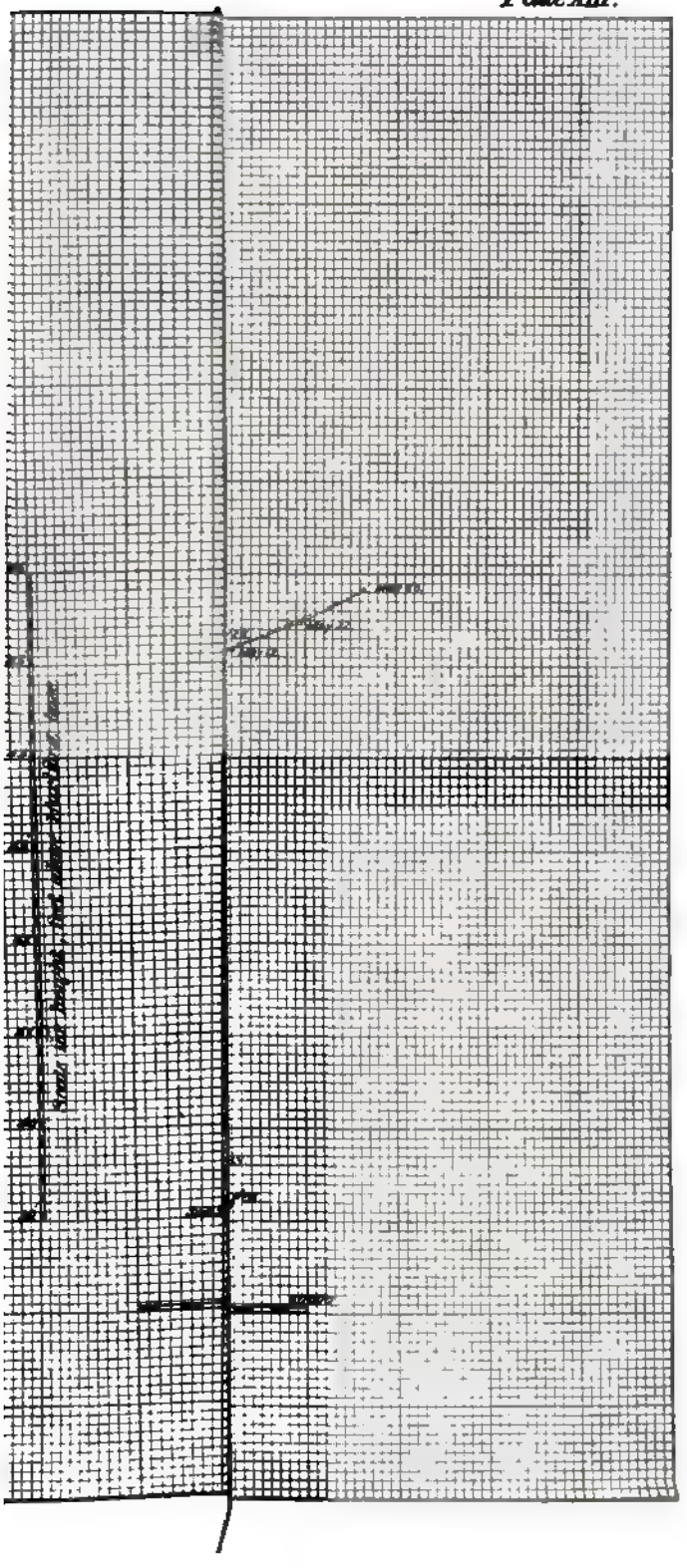


Plate XIV.

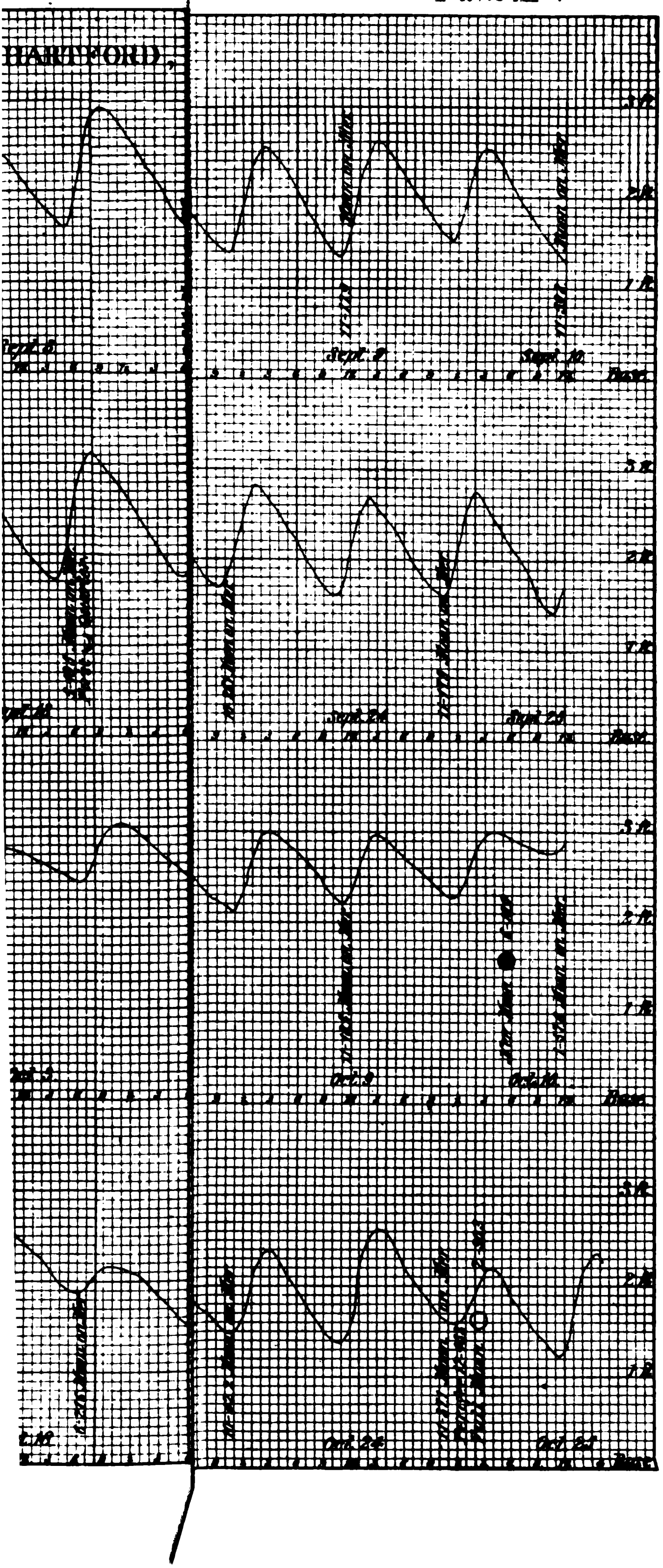
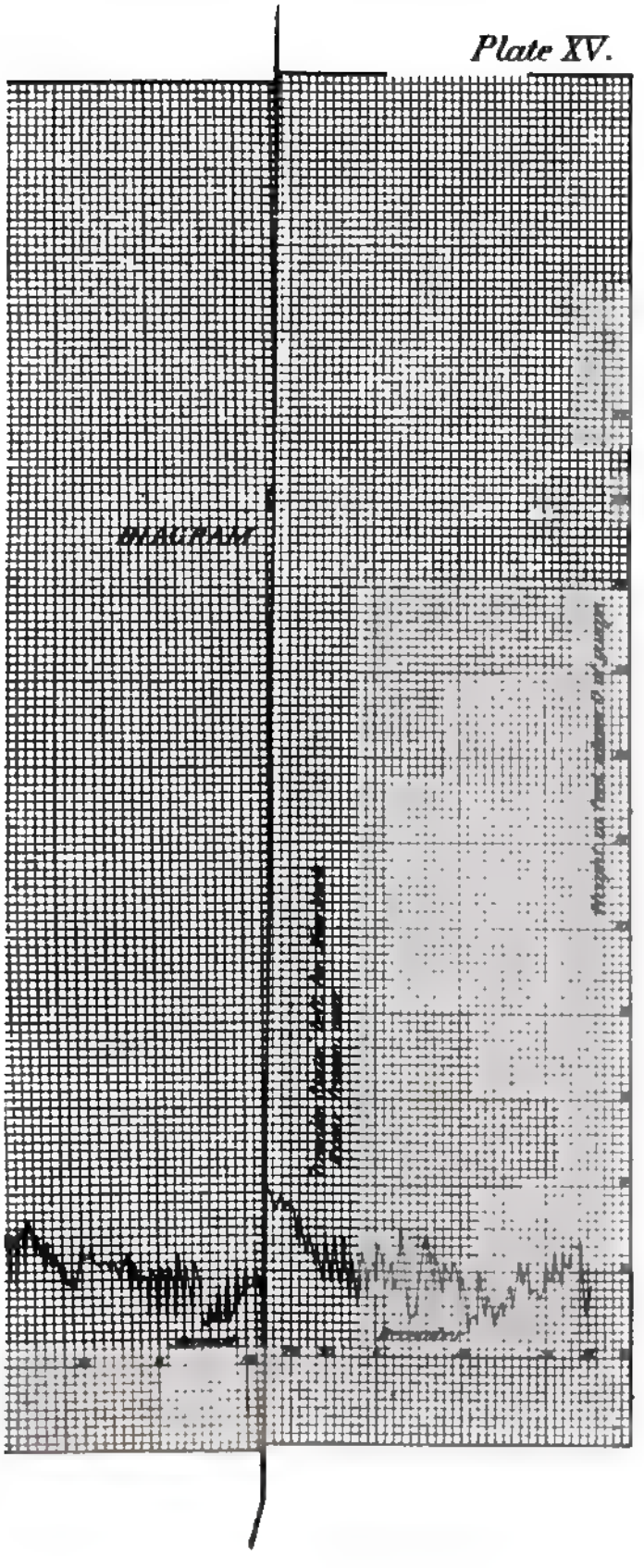
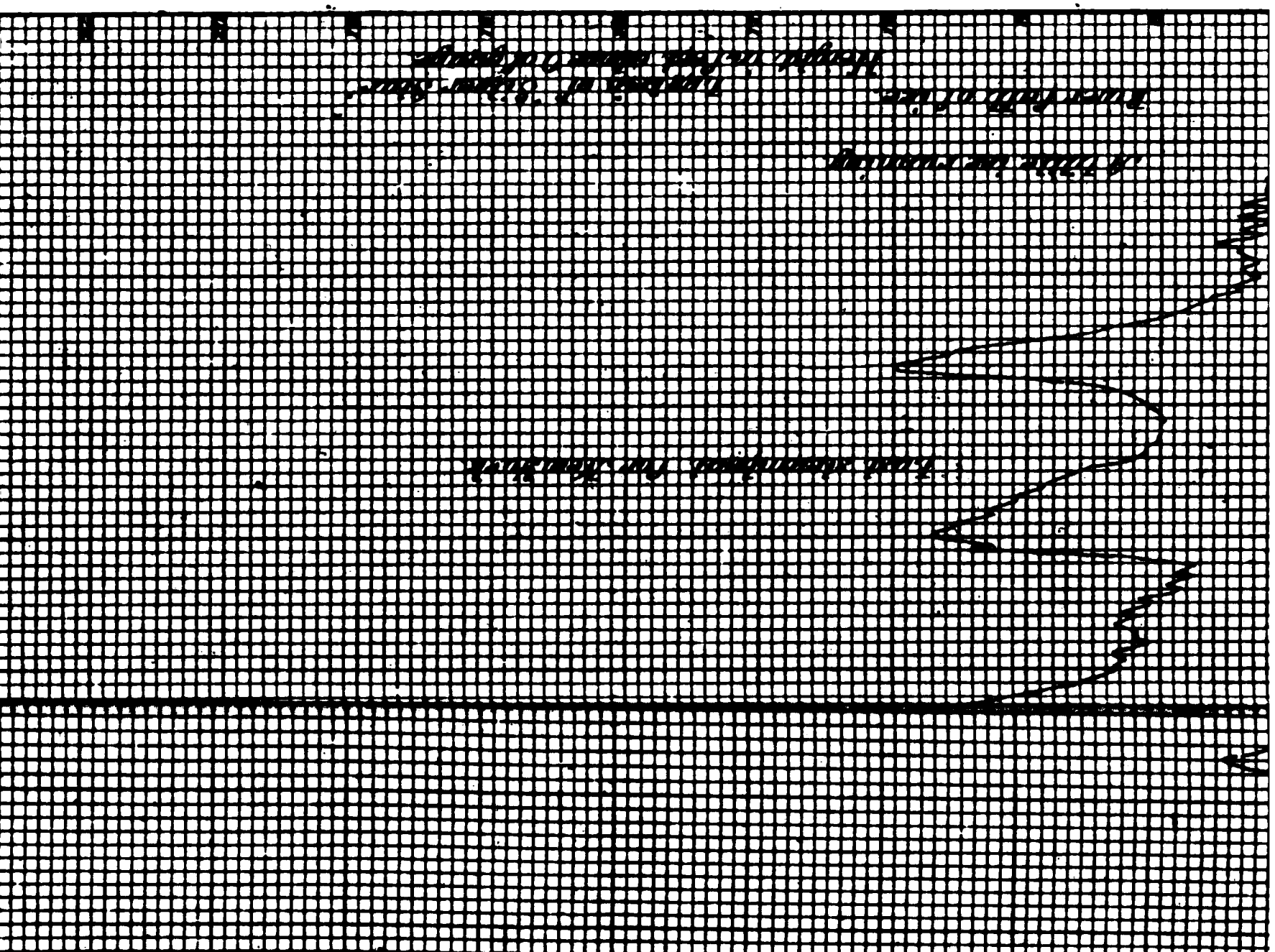


Plate XV.





APPENDIX C.

ANNUAL REPORT OF MAJOR J. W. BARLOW, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1878.

ENGINEER OFFICE, UNITED STATES ARMY,
New London, Conn., July 13, 1878.

GENERAL: I have the honor to transmit herewith the reports of river and harbor works in my charge for the fiscal year ending June 30, 1878.

Very respectfully, your obedient servant,

J. W. BARLOW,
Major of Engineers, U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

C 1.

IMPROVEMENT OF STONINGTON HARBOR, CONNECTICUT.

There being no appropriation, the improvement of this harbor was suspended during the past fiscal year.

The importance of completing the breakwater, designed as a protection both to the local commerce of the harbor and to passing vessels, in stress of weather, has been discussed and acknowledged, and it is but necessary to refer to previous reports on this subject.

The present plan of improvement was adopted by the Board of Engineers convened to investigate the whole question, and received the approval of the department; the proceedings of the board appearing in the Annual Report of the Chief of Engineers for 1876.

As stated in the report for 1877 an appropriation of $25,000 has been expended toward executing this project.

Previous appropriations had been devoted to the removal of Penguin Shoal, in order to facilitate the entrance of vessels to the inner harbor, and to extend the area of that anchorage-ground.

The increased depth of water thus gained allows a heavy sea swell to reach the upper harbor, to the annoyance, at times, of vessels lying at the docks.

The completion of the breakwater off Wampassett Point will no doubt largely prevent this; but its chief office will be found in the protection afforded to the general commerce of the sound, inasmuch as a secure harbor of refuge will be obtained at the extreme eastern end of Fisher's Island Sound, where coasting vessels can find shelter during storms, and whence they can immediately reach the open sea. With the present appropriation it is proposed to carry on the construction of the breakwater as far as the funds will permit. At the present low prices for riprap granite, it is hoped that a length of about 600 linear feet can be added.

In the original design there was provision for a coping of heavy stone. This coping has been omitted from the section already built, and thus far no necessity is seen for adding it. A great saving will result from dispensing with it altogether, and it is recommended that until it shall be found necessary the coping be omitted.

The following amounts have been appropriated for the improvement of this harbor:

March 3, 1873, dredging between old breakwater and steamboat docks...	$25,000 00
June 23, 1874, dredging on Penguin Shoal	20,000 00
March 3, 1875, commencement of breakwater off Wampassett Point.....	25,000 00
June 18, 1878, continuing breakwater off Wampassett Point.....	40,000 00
Estimate of June, 1875, for executing approved project.....	231,000 00

Stonington is a port of entry for the Stonington collection district. There is a light-house on Stonington Point, and a light-ship 2 miles southwest of Wampassett Point. Fort Trumbull is 12 miles distant.

The following statistics have been received from Capt. George Hubbard, collector of customs:

Number of foreign vessels arrived from foreign ports	1
Number of foreign vessels cleared for foreign ports	1
American vessels arrived from foreign ports	2
American vessels cleared for foreign ports	2
Total number of vessels of all classes entered and cleared during the fiscal year ending June 30, 1878.....	633
Total tonnage.....	1,079,185
Estimated value of cargoes received.....	$22,378,440
Estimated value of cargoes exported	$21,940,000
Number of vessels of all classes entering the harbor for refuge during the year	2,250
Number of vessels passed light-ship	21,430

Draught of vessels using this harbor, from 3 to 14 feet.

COLLECTIONS.

Duties on imports	$206 42
Hospital tax	787 36
Miscellaneous receipts	639 86
	1,633 64

Money statement.

July 1, 1877, amount available.....	$44 63	
Amount appropriated by act approved June 18, 1878	40,000 00	
		$40,044 63
July 1, 1878, outstanding liabilities.....		40 00
July 1, 1878, amount available		40,004 63
Amount (estimated) required for completion of existing project.....		166,536 00
Amount that can be profitably expended in fiscal year ending June 30, 1880 .		75,000 00

C 2.

IMPROVEMENT OF THAMES RIVER, CONNECTICUT.

Since the expenditure of the appropriation made in 1872 for dredging, no work has been done on this improvement.

The plan then completed provided for the excavation of a channel 100 feet wide and 11 feet deep at mean low-water through the shoals obstructing the river at frequent intervals between the city of Norwich and Indian Point, about 3 miles below.

Since the completion of this work freshets in the upper tributaries

have brought down additional material, which has been deposited as before.

These facts were presented in my letter of February 3, 1877, and in the annual report for that year an appropriation of $6,000 was requested with which to make an examination of the shoals and to commence dredging.

Congress at the last session directed an examination of this river to be made under the general appropriation for "examinations and surveys," &c., and also appropriated $10,000 for improving the river.

Under the above authority the necessary surveys for the preparation of estimates of cost of improvement have been made, and a map is now in process of construction to be forwarded as soon as completed.

From the examination it is found that the river since 1872 has shoaled nearly the entire length of the dredged channel, a distance of about 3 miles. The depth at mean low-water where the deposits have occurred now varies from 8 to 11 feet, and on the Middle Ground near Norwich the depth is but 5 feet.

It is believed that a large portion of this deposit is brought from the adjoining dumping-grounds which are washed by the current of the river during freshets. This consideration, together with the difficulties attending a further deposit of material at the sides of the river behind the wing-dams, has led to the determination to abandon those dumping-grounds and rely upon transporting the dredged material below the mouth of the river. The towage will be long, about 14 miles, but, everything considered, it is believed this method of disposing of the material will finally prove most economical.

A communication from citizens of Norwich, a copy of which, with accompanying statistics, is added to this report, presents the importance of improving the navigation of this river, and urges the adoption of a depth greater than was given by the plan executed in previous years. In consideration of the fact that the mean rise and fall of tide in this part of the river is but 3.1 feet, a depth of 14 feet at mean low-water would afford no better facilities for navigation than 11 feet at many harbors on the sound, where the tidal variation is much greater.

Following are estimates for dredging in this section of the river under the two plans considered:

1st. To make the channel from Indian Point to Norwich 100 feet wide and 11 feet deep at mean low-water will require the removal of 132,000 cubic yards of material, at 30 cents per yard, $39,600.

2d. To excavate a channel of same width to a depth of 14 feet at mean low-water would require the removal of 300,000 cubic yards, at 25 cents per yard, $75,000.

The lower rate for dredging under the second plan is based on the fact that this depth will give a better working face, and the supposition that the annual expenditures will be larger than under the first plan.

With the sum now available it is not considered expedient to attempt a greater depth than 11 feet, and it is proposed to expend these funds in dredging at the shoalest places, with a view to the immediate wants of navigation. I would, however, recommend to favorable consideration the second plan, to be carried into execution under future appropriations.

The following sums have been appropriated for the improvement of this river:

Expended for wing-dams:	
1836	$10,000 00
1837	20,000 00
1838	10,000 00
Expended for dredging:	
1866–'67	82,000 00
1871	15,000 00
1872	10,000 00
1878	10,000 00
	157,000 00

Following are the communications and statistics above mentioned.

COMMERCIAL STATISTICS.

NORWICH, *July* 11, 1878.

SIR: The undersigned citizens of Norwich, learning that you have in charge the expenditure of the $10,000 appropriated by Congress at its recent session for the improvement of the river Thames, would respectfully represent that for the purpose of protecting and advancing the commercial interests of the city of Norwich it is vitally important that the navigation of the river Thames should be immediately improved.

This can only be done by deepening the channel of said river where it is less than 14 feet in depth, as it is in many places between the wharves of said city and the navy-yard, on the east bank of said river, and at certain points widening the same.

There are several lines of steam and sail vessels constantly plying between the city of Norwich and foreign and domestic ports. Said city is also constantly visited by transient vessels. Many vessels are engaged in the importation of West India goods and other descriptions of merchandise, and in the exportation of large quantities of American products, and coasting-vessels are busy in bringing to Norwich large supplies of cotton, lumber, coal, iron, flour, grain, and provisions of all descriptions, which articles are carried into the interior by railroads and distributed not only through Connecticut, but to very many of the cities and manufacturing towns of New England.

It may be important to state the fact that fully 90 per cent. of the duties received at New London for this collection-district is paid by Norwich merchants. We also submit with this communication certain statistics which corroborate in part the statements which we have made.

(Signed by H. H. OSGOOD, *Mayor, city of Norwich*, and sixty-six others.)

Col. J. W. BARLOW,
Corps of Engineers, U. S. A.

STATEMENT OF MERCHANDISE RECEIVED BY THE NORWICH AND WORCESTER RAILROAD AT THEIR DOCKS IN NORWICH FOR YEAR ENDING MAY 30, 1878.

Three hundred and seventy-five vessels coal, sand, steel, &c., 115,000 tons. Average 300 tons burden; 40,000 tons promiscuous freight; cotton, wool, rags, flour, &c., 40,000 tons.

We receive vessels at Allyn's Point "with coal principally" 7 miles below with 12, 14, and 15 feet draught of water, which would come to Norwich if depth of water would permit, thereby receiving greater dispatch and increasing the volume of coal-carrying business which is driven to other routes in consequence of not being able to charter carrying craft of proper draught of water for Norwich.

There is received here by dealers in coal and lumber, brick, &c., as follows: 100,000 tons of coal, from 2,000,000 to 4,000,000 feet of lumber, and 2,000,000 brick and over, and other merchandise, such as flour, grain, and feed, which cannot be accurately estimated, but will count in aggregate very largely, and amount to a great many thousand tons.

GEO. A. HARRIS,
Freight Agent.

STATEMENT OF MESSRS. J. M. HUNTINGTON & CO., NORWICH, CONN., JULY, 1878.

Average cargoes from foreign ports yearly, 16. Amounts in hogsheads sugar and molasses imported into district of New London fully 5,000; other imports, some 500 tons

EXPORTS.

erage 11 to 12 outward cargoes of nearly all American produce, such as flour, l, provisions, and cooper stocks, cotton goods, and also about 200 tons foreign rice; age, four years. Coastwise they annually receive 2,000 tons coal; scrap-iron, ore , &c., 2,000 tons, and ship from their mill about 12,000 tons iron yearly. They pay 90 per cent. of the duties received in the district; average four years over $60,000, years over $80,000. Have the only bonded warehouse in the district, and have e wharf-room and water-front than any private firm in the district.

J. M. HUNTINGTON & Co.

ly attention has been called to a recently established channel of mmerce through New London Harbor, including, at the terminus of New London Northern Railroad, extensive wharf accommodations, ich have been built as a connecting link between certain railroad s and ocean transportation.

A petition emanating from responsible business firms of New London l Norwich, a copy of which follows, sets forth the desirability of im- ving this channel of communication by the removal of certain rocks w impeding navigation.

PETITION.

NEW LONDON, CONN., *July* 1, 1878.

IR: The undersigned, interested in commerce and navigation in and about New ndon, Conn., desire to call your attention to the existence in the river Thames near large wharf in New London, lately built by the New London Northern Railroad mpany, of sundry single rocks or bowlders at the bottom of the river, covered by more than 9 feet of water at low tide, and so situated as to be impediments to the navigation of the river at that point.

his wharf has been built at a cost of $175,000, has an area of more than 4 acres, nearly one-half mile of water frontage, part of which is obstructed by these rocks o its approaches.

his wharf, by means of the railroad connections of the New London Northern Rail- d, brings better tide-water facilities to a large portion of New England than are to had elsewhere. To us it seems that the aid of the government may be fairly oked for the clearance of these obstructions, and we respectfully request you to ke an examination of the premises, with a view to recommending such action by government as may seem to you reasonable and called for on public considerations.

Respectfully, yours,

C. A. WILLIAMS & Co., AND OTHERS.

ol. J. W. BARLOW,
Corps of Engineers, U. S. A.

In response to this petition an examination of the locality in question s been made and the facts as stated verified.

The wharf is certainly a magnificent structure, of vast proportions, mense water frontage, and thoroughly built. The main channel of e Thames River with a depth of from 5 to 6 fathoms flows but a few ndred feet east of it, and sufficient water has been provided in its mediate vicinity.

A shoal containing bowlders was found midway between the river- annel and the wharf. This is a serious obstacle and should be re- oved. The following estimates are presented:

To remove the shoal and bowlders to a depth of 16 feet at mean low-water will require the excavation of 125 cubic yards of bowlders, at $5 per yard	$625 00
7,000 cubic yards of gravel and mud, at 15 cents per yard	5,550 00
Add for contingencies	625 00
	6,800 00

It is recommended that this work be included in the general project for improving the Thames River, and the above sum from the next appropriation be expended in its execution.

SUMMARY OF ESTIMATES RECOMMENDED FOR THE IMPROVEMENT OF THE THAMES RIVER.

Dredging channel 100 feet wide to a depth of 14 feet at mean low-water from Indian Point to Norwich	$75,000 00
Removal of shoals near New London and Northern Railroad wharf	6,800 00
Total	81,800 00

Mr. John A. Sibbits, collector of customs for the port of New London, in presenting the following statistics, remarks:

It is impossible to state the draught of water or the number of vessels of all classes entering the harbor during the year. I can state, however, from observation, that frequently, in heavy weather, from 100 to 150, or even a larger number of vessels seek refuge in this harbor.

I would also state, in answer to your inquiry, that in my judgment further harbor improvements would tend to the increased use of the harbor for commercial purposes generally.

COLLECTIONS.

Duties on imports	$70,820 63
Tonnage dues	585 90
Hospital tax	1,848 83
Miscellaneous receipts	4,101 10
	77,356 46

Number of foreign vessels arrived from foreign ports	14
Number of foreign vessels cleared for foreign ports	10
American vessels arrived from foreign ports	19
American vessels cleared for foreign ports	10
Total number of vessels of all classes entered and cleared during the fiscal year ending June 30, 1878	84
Total tonnage of the district (193 vessels) ..... tons..	20,134.74
Estimated value of cargoes imported	$255,987 92
Estimated value of cargoes exported	75,390 00

New London, near the mouth of the Thames River, is a port of entry.
Forts Trumbull and Griswold, near the mouth of the river, command the channel.
The New London light-house is situated at the entrance, on the west shore.

Money statement.

Amount appropriated by act approved June 18, 1878	$10,000 00
July 1, 1878, amount available	10,000 00
Amount (estimated) required for completion of existing project	81,800 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.	25,000 00

C 3.

IMPROVEMENT OF NEW HAVEN HARBOR, CONNECTICUT.

No work has been done at this harbor during the past fiscal year, as no appropriation was made at the previous session of Congress.

With the funds appropriated at the last session, the channel between Fort Hale and Long Wharf will be deepened to 16 feet at mean low-water, and widened from 200 to about 325 feet.

This improvement will afford great relief to the shipping interests, as it will permit an increased number of vessels to anchor below the wharves without, as formerly, impeding the passage of vessels to and from the upper harbor.

New Haven being the largest city in Connecticut, and one of the

memorial, with accompanying papers, was printed as House Ex. o. 162, Forty-third Congress, second session, and contains a large t of valuable information relating to the commercial statistics of Haven.

eferring to the arguments therein given, I respectfully renew my nendation that the subject receive favorable consideration. As ior of refuge its position renders it especially desirable. Being midway between Throg's Neck and the Thames River and oppo- e widest and most dangerous portion of the Sound, a breakwater ould afford a convenient stopping place for that immense and in- ig traffic carried on by means of barges ill adapted to withstand erity of the storms which frequently occur on the Sound. This of commerce has grown rapidly during the past few years and probably receive a fresh impetus by increasing its security through ovision of frequent safe resting places along its routes.

argument has been advanced that a breakwater in the vicinity ht House Point would so concentrate and strengthen the ebb to produce a material scouring effect on the bar below Fort Hale. l this theory prove correct the construction of the breakwater result in a diminished expenditure for dredging, and as this would at that part of the harbor where, from the nature of the deposit, nt dredging is to be expected, the aggregate saving would be of mportance.

mates were made in January, 1875, for a breakwater at the mouth harbor to cost, according to location, from $248,000 to $465,000, r enlarging the main ship-channel to the city, depending upon n adopted, from $208,000 to $416,000.

ild these plans meet with approval, it is recommended that work breakwater be undertaken at an early date, and for this purpose propriation of $100,000 could be profitably expended during the scal year.

following amounts have been appropriated for the improvement harbor since 1866:

1870	$15,000 00
[illegible]	40,000 00

COMMERCIAL STATISTICS.

The collector of the port presents the following letter and statistics:

CUSTOM-HOUSE, NEW HAVEN, CONN.,
Collector's Office, July 11, 1878.

SIR:

* * * * * * *

In reference to the effect of the further improvement of the harbor I have the honor to say that in my judgment the commerce of New Haven would be very largely increased within a few years if the channel was widened and the sand-bars removed, so that larger vessels could come to the dock.

The importance of the harbor as a place of refuge can hardly be increased, since it is eagerly sought now, but its security would be increased by a breakwater, and there is no more important point in reference to the security of vessels than this in the Sound.

Very respectfully, yours,

CYRUS NORTHRUP.

J. W. BARLOW,
Major of Engineers, Brevet Lieutenant-Colonel, U. S. A.

COLLECTIONS.

Duties on imports	$282,267 58
Tonnage dues	1,593 70
Hospital tax	2,102 36
Miscellaneous receipts	4,269 46
	290,233 10
No. of foreign vessels arrived from foreign ports	32
No. of foreign vessels cleared for foreign ports	17
American vessels arrived from foreign ports	49
American vessels cleared for foreign ports	19
Total number of vessels of all classes entered and cleared during the fiscal year ending June 30, 1878	1,583
Total tonnage	1,091,459
Estimated value of cargoes received	$1,053,159
Estimated value of cargoes exported	$3,568,741
Draught of vessels frequenting the harbor	10 to 20 feet.
No. of vessels of all classes entering the harbor for refuge during the year (estimated)	8,000

Through the courtesy of a number of persons, the following information relating to the commerce of Long Island Sound, and bearing upon the subject of a harbor of refuge, has been received.

The keeper of the Bartlett's Reef light-ship reports the following vessels as having passed the reef during the year ending June 30, 1878:

Steamers	7,951
Sloops	7,631
Schooners	21,078
Brigs	327
Barks	143
Ships	17
Barges in tow	934
	38,081

The president of the Providence and Stonington Steamboat Company estimates the value of merchandise annually transported over their two lines to be from $93,000,000 to $124,000,000.

The agent of the Fall River line of steamers estimates the value of merchandise annually carried by that line to be $36,000,000.

The general manager of the Export Lumber Company of New York City gives the number of cargoes of lumber arriving at that city through Long Island Sound as follows:

For 1874, 867. For 1875, 916. For 1876, 755. For 1877, 808.

These cargoes are estimated at from 150,000 to 175,000 feet each; also, f coal and plaster, 100 cargoes per annum of about 250 tons each.

Capt. C. H. Townsend, of New Haven, estimates the quantity and alue of coal, iron, and fish annually carried through the Sound as fol-ows:

oal, 2,000,000 tons, valued at	$9,000,000 00
ron, valued at	5,000,000 00
ish (shell and scale), valued at	7,500,000 00

Messrs. De Forrest & Hotchkiss, lumber-merchants of New Haven, resent the following estimate:

Lumber received at New Haven, through the Sound, during the last ten years, from),000,000 to 50,000,000 feet annually, valued at $1,000,000.

The New York and New Haven Steamboat Company estimate the alue of merchandise transported by their line at $60,000,000 to 75,000,000 annually.

P. P. Avery, esq., ship-chandler at New Haven, estimates, by reference) memoranda in his possession, the number of vessels arriving at New aven as follows:

sail-vessels per day	3,650
barks in tow, per day	1,825
steamers, per day	1,919
	7,394

The following "Return of vessels which have passed by or in vicinity light-house on Southwest Ledge during the year ending 30th day of ane, 1878," is presented by Mr. E. Thompson, principal light-keeper:

Ships.	Barks.	Brigs.	Schooners.	Sloops.	Steamers.	Total.
25	31	209	5,614	1,745	4,181	10,378

These statements are only a partial exhibit of the commerce of the ound, as a number of steamboat lines are not mentioned, and but a frac-on of the traffic carried on by sailing-vessels and barges is included.

In this connection it is pertinent to again refer to the report on New laven Harbor printed as House Ex. Doc. No. 162, Forty-third Congress, econd session, and to invite attention to the facts and conclusions pre-ented by the Hon. H. G. Lewis, mayor, in his letter dated February 5, 875.

The views of Prof. W. P. Trowbridge and Capt. C. H. Townsend, ogether with other information therein, will be found of special interest n their bearing upon the statistics of this harbor, and the desirability f its further improvement.

Money statement.

uly 1, 1877, amount available	$2,612 23	
mount appropriated by act approved June 18, 1878	25,000 00	
		$27,612 23
uly 1, 1878, amount expended during fiscal year	467 61	
uly 1, 1878, outstanding liabilities	200 00	
		667 61
July 1, 1878, amount available		26,944 62
Amount (estimated) required for completion of existing project:		
Breakwater		400,000 00
Dredging		180,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		100,000 00

C 4.

IMPROVEMENT OF MILFORD HARBOR, CONNECTICUT.

With the exception of slight repairs upon the long jetty, no work has been done by the government during the past year at this harbor. The improvements previously made remain in about the same condition as at the date of the last annual report, and the dredged channel from the vicinity of Mr. William Merwin's wharf to the Sound retains its depth and proves of great advantage to the local interest of Milford. It also affords convenient anchorage-ground in bad weather for fishing-smacks and other vessels of light draught.

Mr. Merwin, a resident of Milford, states that the local commerce of Milford was about the same during the past year as in preceding years, but that the outer bay has been much more freely used as an anchorage-ground than formerly, owing to the opportunity afforded by the dredged channel for vessels to reach the inner harbor in case of sudden storms, and adds:

> It is of vast importance to commerce that the breakwater be built off Welch's Point; we would then have the best harbor on the Sound.

In previous reports reference has been made to the convenience of this bay as a harbor of refuge for light vessels should it be protected by a breakwater at Welch's Point, and estimates were given in 1871, modified in the report for last year.

This work can be built for $45,000, and, beside serving to cover anchorage now exposed to easterly and southerly storms, would effectually protect the bluffs above from erosion, and prevent the *débris* from washing into the channel.

With the appropriation for the next fiscal year it is proposed to continue the dredged channel to the town wharf, and to complete the long jetty now nearly finished.

The following sums have been appropriated for the improvement of this harbor:

June 23, 1874—Construction of jettties at Welch's Bluffs	$5,000 00
March 3, 1875—Long jetty at mouth of Indian River and dredging	13,000 00
June 18, 1878	10,000 00
	28,000 00
Estimates of 1872 for improving this harbor	85,000 00
Additional estimate of 1876 for continuing dredging	8,000 00

Milford is in the New Haven collection-district, New Haven being the nearest port of entry. Amount of revenue collected for past fiscal year, $290,233.10.

Money statement.

July 1, 1877, amount available	$445, 84	
Amount appropriated by act approved June 18, 1878	10,000 00	
		$10,445 8
July 1, 1878, amount expended during fiscal year		313 0
July 1, 1878, amount available		10,132
Amount (estimated) required for completion of existing project		45,000
Amount that can be profitably expended in fiscal year ending June 30, 1880.		45,000

C 5.

IMPROVEMENT OF HOUSATONIC RIVER, CONNECTICUT.

The improvement of this river has consisted in the removal of bars rmed by the winter and spring freshets. Of these the most troublesome is that known as Drew's Bar, near the west bank of the river, and out 4 miles below Derby.

The constant recurrence of this obstruction is owing to the position of small rock which formerly lay directly in the channel with good water either side. The rock being a serious obstacle, it was desirable to nove it or change the position of the channel. The latter plan being emed least expensive was adopted, and in 1872 a jetty connecting the k with the west shore was built.

As stated in the annual report for 1877, the bar has been dredged off r times since the construction of the jetty. It is now proposed to ertain the cost of the removal of the jetty together with the rock, and, uld such cost be found not excessive, to present at an early day a ject and estimate for the work. A reconnaissance of the river will made as soon as possible, when the position at Drew's Rock and Bar l be carefully examined with a view to the above project.

No improvement has yet been attempted upon the bar at the mouth of river, where the least depth at mean low-water last season was but 4 t. It has hitherto been considered that a permanent channel through s bar would require the construction of one or more jetties, involving expense disproportioned to the amount of commerce likely to be benesd. Upon a further study of the subject should it be found that a less tly method can be applied to advantage, corresponding plans and esmates will be presented for consideration. It is certainly very desirable improve the condition of the entrance to this river if it can be accomshed within reasonable limits as to expense.

The following appropriations have been made for the improvement of is river:

rch 3, 1871	$15,000 00
ne 10, 1872	15,000 00
rch 3, 1873	10,000 00
ne 23, 1874	10,000 00
rch 3, 1875	5,000 00
ne 18, 1878	5,000 00
Total	60,000 00

No general plan for this improvement has been made, estimates having een presented from year to year to remove bars formed by winter and pring freshets.

Housatonic River is the dividing line between New Haven and Fairfield collection districts. Amount of revenue collected during the year ending June 30, 1878, was at Bridgeport $4,561.69.

There is a light-house on Stratford Point at the mouth of the river, and on Stratford Shoal midway between the north and south shores of the Sound.

The nearest defensive work is Fort Hale, New Haven Harbor, 13 miles distant.

The following statistics relating to the commerce of this river have been received:

Total number of vessels of all classes entered and cleared during the fiscal year ending June 30, 1878, 126; total tonnage, 25,200; estimated value of cargoes received, $110,000; estimated value of cargoes exported, $5,000; draught of water, 7 feet.

Number of vessels of all classes entering the harbor for refuge during the year, 50.

Money statement.

July 1, 1877, amount available	$17 73	
Amount appropriated by act approved June 18, 1878	5,000 00	
		$5,017 73
July 1, 1878, amount available		5,017 73
Amount that can be profitably expended in fiscal year ending June 30, 1880		5,000 00

C 6.

IMPROVEMENT OF BRIDGEPORT HARBOR, CONNECTICUT.

During the last fiscal year the appropriation of $10,000, made by act of Congress approved August 14, 1876, was applied to deepening and widening the upper part of the harbor from the steamboat-wharf to the lower bridge.

A contract at rates extremely favorable to the government, viz, 8⅞ cents per cubic yard for material removed and deposited in the sound, was made with the Messrs. Beardsley, of Bridgeport. Work was begun in July, 1877, and completed in the following September.

As a result of this dredging, the 9-foot channel has been widened to 450 feet, greatly facilitating the movements of vessels and adding much needed space to the anchorage in this part of the harbor.

With a portion of the appropriation made at the last session of Congress, and in compliance with a provision of the act, it is proposed to devote at least $5,000 to the excavation of a channel, 100 feet wide and 9 feet deep at mean low-water, between the lower bridge and the horse-railroad bridge, and with the balance remaining after completing this work to widen the 12-foot channel from the sound to the inner beacon.

The following amounts have been appropriated for the improvement of Bridgeport Harbor:

March 3, 1871—Breakwater	$20,000 00
June 10, 1872—Breakwater	40,000 00
March 3, 1873—Dredging	30,000 00
June 23, 1874—Dredging	20,000 00
March 3, 1875—Dredging	15,000 00
August 14, 1876—Dredging	10,000 00
June 18, 1878—Dredging	10,000 00
	145,000 00

Estimate of 1871 for the improvement of this harbor, $196,000.

Bridgeport is the port of entry of the Fairfield collection district; the nearest light-house is at the entrance of the harbor on the west side. Fort Hale, New Haven Harbor, 16 miles distant, is the nearest work of defense.

COMMERCIAL STATISTICS.

The following letter and accompanying statistics relating to the commerce of this port have been received:

CUSTOM-HOUSE, BRIDGEPORT, CONN.,
Collector's Office, July 10, 1878.

SIR: I have the honor to acknowledge the receipt of your letter of the 3d instant, and inclose the statement requested. The estimate of the total number of vessels entering and clearing, their tonnage, and the value of their cargoes, is necessarily an approximate one.

I am of the opinion that the deepening of the water on the bar and in the channel in connection with the building of a breakwater, has already been found to be

provement, and with a further outlay in the same direction the harbor of rt, situated as it is in one of the most accessible and advantageous positions etween New York and Boston, at the terminus of two railroads, one (the ıic) making direct connections with other lines to the great West and the hould invite a largely increased coastwise and foreign trade, and might be e of the most important ports for the shipment of grain, flour, &c., in the An elevator already erected rendering the shipment of such articles easy enient.

ry respectfully, your obedient servant,

J. S. HANOVER,
Collector.

W. BARLOW,
Corps of Engineers, U. S. A.

COLLECTIONS.

ı imports	$1,416 57
dues	103 50
-tax	1,560 63
ıeous receipts	1,480 99
	4,561 69
of foreign vessels arrived from foreign ports	25
of foreign vessels cleared for foreign ports	23
ı vessels arrived from foreign ports	4
ı vessels cleared for foreign ports	0
mber of vessels of all classes entered and cleared during the fiscal ıding June 30, 1878	7,229
nuage	1,269,632
d value of cargoes received	$25,181,100
d value of cargoes shipped	$24,147,000
of water, 8 feet at low-water. Number of vessels of all classes ıg the harbor for refuge during the year	900 to 1,000

Money statement.

877, amount available	$9,886 95	
appropriated by act approved June 18, 1878	10,000 00	
		$19,886 95
878, amount expended during fiscal year		9,754 22
878, amount available		10,132 73
(estimated) required for completion of existing project		30,000 00
that can be profitably expended in fiscal year ending June 30, 1880.		20,000 00

t of proposals received June 21, 1877, for improving harbor at Bridgeport, Conn.

me.	Address.	Price per cubic yard. Outer bar.	Price per cubic yard. Above the steamboat-wharf.	To commence—	To complete—	Remarks.
		Cents.	*Cents.*			
Brainard...	Albany, N. Y....	14½	9	July 1, 1877	Nov. 30, 1877	
mond.....	Providence, R. I.	13	9	July 1, 1877	Nov. 30, 1877	
rd.....	Albany, N. Y....	16	9	July 1, 1877	Nov. 30, 1877	
. J. Beards-	Bridgeport, Conn	15	8⅞	July 1, 1877	Dec. 1, 1877	
tt & Daly...	Cohoes, N. Y....	18	9½	July 1, 1877	Nov. 30, 1877	Bid not in duplicate.

t made with Messrs. H. N. & A. J. Beardsley, at 8⅞ cents. All the work to be done above steam-f.

C 7.

IMPROVEMENT OF SOUTHPORT HARBOR, CONNECTICUT.

With the appropriation of $5,000 made by act of Congress approved August 14, 1876, the following work has been done at this harbor:

An agreement was entered into with Mr. J. H. Fenner, of Albany, N. Y., under which a channel 60 feet wide and 4 feet deep at mean low-water was dredged from the outer beacon to above the end of the breakwater. The vacant spaces between the walls of the dike were filled with a portion of the dredged material, and the remainder deposited in deep water outside the harbor.

Seventeen cents per cubic yard was paid for the latter work, and 37 cents for the former. Under this agreement, about 15,000 cubic yards of material have been removed, making a channel 60 feet in width and 4 feet deep at mean low-water. The repairs upon the dike by filling void spaces between the walls with material from the channel have been completed.

It being desirable to make the width of the dredged channel 100 feet, an additional sum of $5,000 is needed for this purpose, which could be profitably expended during the next fiscal year.

Following are the amounts appropriated for this harbor since 1838:

March 3, 1875	$5,000 00
August 4, 1876	5,000 00
	10,000 00

Southport is in the Fairfield collection district, of which Bridgeport is the port of entry. The amount of revenue collected there for the fiscal year ending June 30, 1878, was $4,561.69. The nearest light-house is on Penfield Reef, 3¼ miles from the harbor. Fort Hale, New Haven Harbor, the nearest work of defense, is 24 miles distant.

COMMERCIAL STATISTICS.

The following statistics relating to the commercial business of this port have been furnished by J. H. Perry, esq.:

Total number of vessels of all classes entered and cleared during the fiscal year ending June 30, 1878	200
Total tonnage	2,500
Estimated value of cargoes received	$110,000
Estimated value of cargoes shipped	$125,000
Number of vessels of all classes entering the harbor for refuge during the year	100

Money statement.

July 1, 1877, amount available		$5,063 93
July 1, 1878, amount expended during fiscal year	$3,185 19	
July 1, 1878, outstanding liabilities	1,226 05	
		4,411 24
July 1, 1878, amount available		652 69
Amount (estimated) required for completion of existing project		5,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		5,000 00

C 8.

PROVEMENT OF PORT JEFFERSON HARBOR, LONG ISLAND, NEW YORK.

The appropriation of $6,000, made by act of Congress approved August 1876, was applied to repairing the east jetty and the excavation of a through the bar, in about equal proportions.

The work upon the breakwater was executed under contract with ssrs. Ingerson and Molthrop, and consisted in adding stone to its tire length, widening, strengthening, and raising the structure, with iew to more thoroughly arresting the flow of sand into the channel m the direction of Mount Misery.

The interval between the shore end of the jetty and the plank fence, ough which large quantities of sand had been driven by easterly rms, was securely closed by a stone extension of the jetty, and the ace continued still farther inland. The jetty at its sea end was curved t a short distance.

The stone-work was well executed, and has withstood the severe win- gales with trifling injury. A portion of the plank fence, at its extreme shore end above ordinary high-water, was injured during the winter. hen it is considered that the posts of this fence are 8 inches by 8 inches, mber placed 4 feet in the ground, some idea may be had of the action d power of the waves during the concurrence of a severe easterly rm and an abnormally high tide.

One cut through the bar was successfully accomplished. The difficul- s apprehended in dredging on this bar rendered contractors reluctant enter upon the work, and it was therefore decided to make the experi- ent with hired machinery. A satisfactory arrangement was entered to with Mr. M. F. Brainard for the use of his dredge, tug, and scows, $6.50 per hour, working time. As was anticipated, the chief difficulty countered was the tide, which ebbs and flows with such strength that e spuds ordinarily used for holding the dredge in place were inadequate, avy anchors and hawsers being required in addition. The cut when mpleted was 1,300 feet in length, 25 feet in width, and 8 feet deep at mean w-water, where the least depth was previously but 2½ feet. The eam ferry-boat is now able to cross at all stages of the tide. It is ported that the outer end of this cut became partially filled during a evere storm last winter, but afterward cleared itself by the action of the bb tide.

When the jetties have been carried to their proposed length, 9 feet of ater, there is every reason to believe that a channel 8 feet in depth will e self-sustaining, and although the material of this bar is very heavy, eing largely composed of coarse gravel mixed with stones of several ounds weight, it is not impossible that the present cut will increase in width by the augmented force of the current, due to the contraction of the estuary.

The plans for the improvement of this harbor, now in process of execu- tion, contemplate the extension of the jetties to 9 feet of water, and, if found necessary, to excavate by dredging a channel 100 feet wide through the bar. The appropriation of $10,000 made at the last session of Con- gress will be expended in accordance with these plans.

It is hoped, however, that a large part of this excavation will be done by the action of the tidal current when concentrated and strengthened by the completion of the jetties.

The following amounts have been appropriated for the improvement of this harbor:

March 3, 1871	$15,000 00
June 10, 1872	15,000 00
March 3, 1875	15,000 00
August 14, 1876	6,000 00
June 18, 1878	8,000 00
	59,000 00

The original estimates for the improvement of this harbor amounted to $150,000. Modifications in the plan and lower prices for material and labor have quite reduced these estimates. The present project can be completed for $28,000.

Port Jefferson is in the New York collection-district. The nearest light-house is at "Old Field Point," immediately west of the harbor entrance. Fort Hale, New Haven Harbor, 23 miles distant, is the nearest work of defense.

The commerce of this harbor is limited, the aggregate tonnage of vessels belonging to this port being about 16,000 tons. The chief business of the village is ship-building, for which unusual facilities are afforded, and quite a number of vessels, many of large tonnage, are annually built. The importance of this harbor, discussed in several previous reports, consists principally in its availability as a harbor of refuge for the south side of Long Island Sound. Its only drawback is the bar at the entrance. When this is improved, no more perfect shelter than will be afforded by this harbor could be desired.

Money statement.

July 1, 1877, amount available	$11,261 64	
Amount appropriated by act approved June 18, 1878	8,000 00	
		$19,261 64
July 1, 1878, amount expended during fiscal year		10,306 76
July 1, 1878, amount available		8,954 88
Amount (estimated) required for completion of existing project		25,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880		25,000 00

Abstract of proposals received May 24, 1877, for improving harbor at Port Jefferson, L. I., N. Y.

Name.	Address.	Price per ton.	To commence—	To complete—	Remarks.
Francis H. Smith	New York, N. Y	$1 89	June 1, 1877	Oct. 1, 1877	
Asa C. Palmer	Fayetteville, N. Y	1 89	June 1, 1877	Oct. 1, 1877	Not certified to by government officer. Signature not witnessed.
Ingerson & Molthrop	New London, Conn	1 33	June 10, 1877	Oct. 1, 1877	
John Beattie	Guilford, Conn	1 35	June 1, 1877	Oct. 1, 1877	
Cook & Chapman	New London, Conn	1 53	June 1, 1877	Oct. 1, 1877	
David V. Howell	New York, N. Y	1 72½	June 1, 1877	Oct. 1, 1877	

Contract made with Messrs. Ingerson & Molthrop, at $1.33.

C 9.

IMPROVEMENT OF NORWALK HARBOR, CONNECTICUT.

Nothing has been done toward improving the navigation of this river since the expenditure of the appropriation of March 3, 1875. With the sum of $5,000 appropriated at the last session of Congress it is design

n the 60-foot channel dredged to a depth of 6 feet at mean low-
t such places as will most benefit navigation.
desirable that the plan heretofore presented of increasing the
f this channel to 100 feet be executed with as little delay as
e.
following appropriations have been made for the improvement of
rbor:

1872	$10,000 00
1873	10,000 00
1874	10,000 00
1875	7,000 00
1878	6,000 00

ast estimate for completing this improvement provided for the
iture in dredging of $30,000. Of this sum $15,000 can be ad-
eously expended during the next fiscal year.

lk is in the Fairfield collection-district, and Bridgeport is the nearest port of
here the amount of revenue collected during the fiscal year ending June 30,
s $4,561.69.
lk light, on Sheffield Island, is opposite the mouth of the river.
arest works of defense are the fortifications at Throg's Neck, 29 miles distant.

COMMERCIAL STATISTICS.

following statistics have been furnished by E. J. Hill, esq., of
lk:

of American vessels arrived from coastwise ports	764
of American vessels cleared for coastwise ports	333
mber of vessels of all classes entered and cleared during the fiscal nding June 30, 1878	1,097
nnage	98,795

ated value of cargoes received and shipped during the year, from $2,000,000
,000.
ht of water—average, 7 feet 6 inches.
er of vessels of all classes entering the harbor for refuge during the year (esti-
00.)

Money statement.

appropriated by act approved June 18, 1878	$6,000 00
878, amount available	6,000 00
(estimated) required for completion of existing project	24,000 00
that can be profitably expended in fiscal year ending June 30, 1880.	15,000 00

APPENDIX D.

NNUAL REPORT OF LIEUTENANT-COLONEL JOHN NEWTON, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1878.

UNITED STATES ENGINEER OFFICE,
New York, July 13, 1878.

GENERAL: I have the honor to transmit herewith the annual reports pon the river and harbor works temporarily in charge of Capt. James lercur, Corps of Engineers, until August 21, 1877, for the fiscal year nding June 30, 1878.

Very respectfully, your obedient servant,

JOHN NEWTON,
Lieut. Col. of Engineers, Bvt. Maj. Gen., U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers U. S. A.

D 1.

IMPROVEMENT OF HUDSON RIVER, NEW YORK.

Lieut. J. H. Willard, Corps of Engineers, stationed at Albany, N. Y., as remained in superintendence of these works.

The following work was done during the year:

Complete survey from State dam at Troy to South end of Houghtailing Island, New altimore.

Re-examinations after dredging by the State engineer and surveyor.

Complete hydrographic map on scale $\frac{1}{5000}$ in five sheets, giving the latest informaon of the condition of the river at the close of the season of 1877 from Troy to New altimore.

	Feet.
ompletion of first dike, overslaugh system	2, 011
ompletion of second dike, overslaugh system	1, 508 $\frac{6}{10}$
ompletion of second half dike, overslaugh system	448
ompletion of third dike, overslaugh system	2, 610 $\frac{1}{2}$
ompletion of third half dike, overslaugh system	637
ompletion of dike at Bath	831
ompletion of dike at Coeymans	174

Repairs at Hillhouse Island, Beacon Island, Van Wie's Point, Parda Hook Point, and ikes at Coeymans.

Dredging under State appropriation:

	Cubic yards.
etween Albany and Troy	24, 833
etween Albany and New Baltimore	20, 209
Total amount removed	226, 842

This work is located in the fourteenth collection district, Albany being the port of ntry.

The value of imports for the fiscal year was $431,066.70, gold, and the amount of revenue collected on the same was $108,947.23, gold.

The tonnage of the port is 290 vessels, aggregating 45,958.85 tons.

The amount of commerce benefited is estimated at $500,000,000.

Amount of estimate of 1868, $984,304.47.

AMOUNTS APPROPRIATED.

By act of Congress approved June 23, 1866	$50,000 00
By act of Congress approved March 2, 1867	305,188 00
By act of Congress approved July 25, 1868	85,000 00
By act of Congress approved April 10, 1869	89,100 00
By act of Congress approved July 11, 1870	40,000 00
By act of Congress approved March 3, 1871	40,000 00
By act of Congress approved June 10, 1872	40,000 00
By act of Congress approved March 3, 1873	40,000 00
By act of Congress approved June 23, 1874	40,000 00
By act of Congress approved March 3, 1875	40,000 00
By act of Congress approved August 14, 1876	50,000 00
By act of Congress approved June 18, 1878	70,000 00
	889,288 00
Amount expended	820,098 97

Money statement.

July 1, 1877, amount available	$36,860 42	
Amount appropriated by act approved June 18, 1878	70,000 00	
		$106,860 42
July 1, 1878, amount expended during fiscal year	36,771 39	
July 1, 1878, outstanding liabilities	89 03	
		36,860 42
July 1, 1878, amount available		70,000 00
Amount (estimated) required for completion of existing project		95,016 47
Amount that can be profitably expended in fiscal year ending June 30, 1880.		95,016 47

Abstract of bids for constructing pile dikes in the Hudson River near Albany, N. Y. Opened July 31, 1877.

Bidders.	Dike at Bath, 830 feet.	Dike on the overslaugh, 1,400 feet.	Dike on the overslaugh, 2,000 feet.	Aggregate.
Stephen Miles	$5 25	$4 75	$3 98	$18,967 50
William D. Fuller	4 97	3 87	3 37	16,283 10
John H. Marshall	3 74	3 19	2 90	13,370 20

Abstract of contract for constructing pile dike in Hudson River.

Contractor's name.	Residence.	Date of contract.	Subject of contract.	Remarks.
John H. Marshall..	New Baltimore, N. Y..	Aug. 13, 1877	Constructing pile dike at Bath and at overslaugh.	To be completed December 31, 1877.

D 2.

REMOVING OBSTRUCTIONS IN EAST RIVER AND HELL GATE, NEW YORK.

HALLET'S POINT.

The contract with Mr. Emory R. Seward for the removal of 24,000 tons of broken rock from this reef was extended from June 30, 1877, to November 1, 1877; and from the commencement of the year to the closing of the contract there were removed 13,281.97 tons.

the expiration of Mr. Seward's contract proposals were advertised
e removal of 25,000 tons of broken rock, and on November 24,
contract was made with the Atlantic Dredging Company for the
at $2.29 per gross ton, operations to commence on or before Janu-
1878.
ing the interval between the completion of Mr. Seward's contract,
vember 1, 1877, and the commencement of work, on January 1,
by the Atlantic Dredging Company, the work of removing the
n rock was continued by hiring dredges and grapples by the day.
nt of rock removed, 3,293.38 tons.
rations were commenced by the Atlantic Dredging Company on
ry 22, 1878, and have been continued with occasional stoppages
pairs. The location of the grappling-machine on the outer portion
reef exposed it to the strong currents running over it, and during
rger portion of the time work was carried on during the ebb-tide
The amount of rock removed to June 30, 1878, was 6,683.15 tons.

FLOOD ROCK.

funds available on July 1, 1877, being sufficient only to carry on
ork of removing the broken rock at Hallet's Point, no work was
except to remove the shops and storehouses formerly used in the
on Hallet's Point.
survey of this rock and the middle reef has been completed and
d. During the latter part of June, 1878, a few men were em-
l in getting the machinery in order to pump out the mine prepara-
o resuming active operations.

STEAM-DRILLING SCOW.

ing to the want of funds, no work was done by this machine during
ear. On January 28, 1878, it was removed from Smith's wharf,
Point, where it had been lying from the commencement of the
to the foot of Court street, Brooklyn, for the purpose of effecting a
in the cost of wharfage.
works in connection with the removing obstructions in East River
Hell Gate have been under the superintendence of Capt. James
r, Corps of Engineers.

work is in the collection-district of New York.
nearest port of entry is New York City.
amount of revenue collected last fiscal year was $91,992,629.62.
amount of commerce and navigation benefited by the completion of this work
be about ———.
unt asked to be appropriated for fiscal year ending June 30, 1880, $600,000.

ORIGINAL ESTIMATE.

ng reefs at Hell Gate and Diamond and Coenties Reefs.....	$5,139,120 00

AMOUNTS APPROPRIATED.

of Congress approved July 25, 1868	$85,000 00
of Congress approved April 10, 1869.....	178,200 00
of Congress approved July 11, 1870	250,000 00
of Congress approved March 3, 1871.....	250,000 00
of Congress approved June 10, 1872	225,000 00
of Congress approved March 3, 1873.....	225,000 00
of Congress approved June 23, 1874	225,000 00
of Congress approved March 3, 1875.....	250,000 00
of Congress approved August 14, 1876.....	250,000 00
of Congress approved June 18, 1878	350,000 00
	2,288,200 00

Brought forward		$2,288,200
Deduct amount reverted to the United States Treasury	$3,158 55	
Deduct amount allotted to Harlem River	11,000 00	
		14,158
		2,274,041
Amount expended		1,886,735

Amount expended during year ending June 30, 1878.

Removing reef at Hallet's Point	$70,091
Excavations at Flood Rock	9,734
Steam-drilling scow	6,061
Contingencies	154
	86,050

Money statement.

July 1, 1877, amount available	$123,355 78	
Amount appropriated by act approved June 18, 1878	350,000 00	
		$473,35
July 1, 1878, amount expended during fiscal year	86,050 27	
July 1, 1877, outstanding liabilities	4,345 30	
		90,39
July 1, 1878, amount available		382,96
Amount (estimated) required for completion of existing project		2,863,12
Amount that can be profitably expended in fiscal year ending June 30, 1880		600,00

Abstract of bids for removing broken rock from Hallet's Point reef, Astoria, N. Y. Op November 14, 1877.

Bidders.	Price to
Atlantic Dredging Company	
Emory R. Seward	
Morris & Cumings Dredging Company	

Abstract of contract for removing broken rock from Hallet's Point reef, Astoria, N. Y

Contractor.	Residence.	Date of contract.	Subject of contract.	Remarks.
Atlantic Dredging Company.	Brooklyn, N. Y.	Nov. 24, 1877	Removing broken rock from Hallet's Point reef, Astoria, N. Y.	To be complete December 31,

D 3.

IMPROVEMENT OF HARLEM RIVER, NEW YORK.

In the act of June 18, 1878, appropriating $300,000 for this work, i proviso that this amount is not to be available until the right of wa secured to the United States free of cost, and until this is done no op ations will be commenced.

This work is in the collection-district of New York.
Nearest port of entry, New York.
Nearest light-house, North Brother Island.
Amount of duties collected for year ending June 30, 1878, $91,992,629.62.
Amount of commerce to be benefited by this work ——.
The estimate for 15 feet channel is $2,100,000.

Money statement.

nount appropriated by act approved June 18, 1878	$300,000 00
ly 1, 1878, amount available	300,000 00
nount (estimated) required for completion of existing project	1,700,000 00
nount that can be profitably expended in fiscal year ending June 30, 1880.	700,000 00

D 4.

IMPROVEMENT OF PASSAIC RIVER, NEW JERSEY.

From the commencement of the year until January 3, 1878, work was ontinued in clearing the channels from loose stones and bowlders, and redging a shoal near the Erie Railroad bridge. The work was all done y hired labor.

The funds being exhausted, the small drilling-scow was towed to Newrk on January 4, 1878, and laid up.

From the beginning of the year until the close of operations, the folowing work was done:

2,018 cubic yards of stone removed.
5,087 feet of channel cleared.
1,565 cubic yards dredged.

Under the appropriation of $10,000 approved June 18, 1878, it is proosed to continue the clearing the channels of loose stone, and drill and blast a number of large bowlders. This work has been under the superntendence of Capt. James Mercur, Corps of Engineers, since August 20, 1877.

This work is in the collection district of Newark, N. J.
Nearest port of entry Newark, N. J.
Nearest light-house, Passaic light.
Amount of revenue collected, $4,255.40.
Amount of commerce to be benefited by the completion of this work, $1,000,000.

ORIGINAL ESTIMATE.

Middle Bar, dredging	$936 00
Middle Bar, diking	66,375 00
Belleville Bar dredging	15,501 00
Rutherford Park Bar, dredging	14,112 00
Holsman's and small bars above, dredging	12,000 00
Contingencies	15,000 00
	123,924 00

AMOUNTS APPROPRIATED.

By act of Congress approved June 10, 1872	$25,000 00
By act of Congress approved March 3, 1873	25,000 00
By act of Congress approved June 23, 1874	20,000 00
By act of Congress approved March 3, 1875	20,000 00
By act of Congress approved August 14, 1876	10,000 00
By act of Congress approved June 18, 1878	10,000 00
	110,000 00
Amount expended	99,391 08

Money statement.

July 1, 1877, amount available	$8,565 46	
Amount appropriated by act approved June 18, 1878	10,000 00	
		$18,565 46
July 1, 1878, amount expended during fiscal year		7,956 54
July 1, 1878, amount available		10,608 92
Amount (estimated) required for completion of existing project		13,924 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		5,000 00

D 5.

IMPROVEMENT OF EAST CHESTER CREEK, NEW YORK.

Work was continued under contract made March 31, 1877, with John Satterlee for making a cut 100 feet wide, at mean high-water ma and about 2,200 feet in length.

During the year the following work was done:

2,298 cubic yards rock removed.
37,387 cubic yards mud dredged.
993 linear feet of pile dike built.
242¼ linear feet of crib dike built.

Under authority from the Chief of Engineers the following work done by hired labor: 14,855 cubic yards of mud, clay, and bowlders moved from the upper end of the cut near and under the draw-bridge the Boston road, and 16,235 cubic yards from the west bank of the ch nel near the mouth of the creek opposite Goose Island.

Work was suspended on May 12, 1878, as the funds had become hausted. Under the appropriation of $10,000, approved June 18, 1 it is proposed to continue the work of dredging near the drawbridge the Boston Road and opposite Goose Island, and to remove a shoal side of Pelham bridge.

This work has been under the superintendence of Capt. James M cur, Corps of Engineers, since August 20, 1877.

This work is in the collection district of New York.
Nearest port of entry, New York.
Nearest light-house, Stepping Stones.
Amount of revenue collected, $91,992,629.62.
Amount of commerce and navigation benefited by completion of the work woul $2,238,203 annually.

ORIGINAL ESTIMATE.

Basin, purchase of site, 18 acres, at $150	$2,70
Excavation to level of mean low-water, 200,000 cubic yards, at 40 cents	80,00
Excavation of cut, 60,000 cubic yards, at 40 cents	24,00
Diking and reveting banks of cut	12,00
Engineering and contingencies	17,80
	136,50

AMOUNT APPROPRIATED.

By act of Congress approved March 3, 1873	$25,00
By act of Congress approved March 3, 1875	12,00
By act of Congress approved June 18, 1878	10,00
	47,00
Amount expended	36,98

Money statement.

July 1, 1877, amount available	$29,718 87	
Amount appropriated by act approved June 18, 1878	10,000 00	
		$39,71
July 1, 1878, amount expended during fiscal year		29,70
July 1, 1878, amount available		10,01
Amount (estimated) required for completion of existing project		89,500
Amount that can be profitably expended in fiscal year ending June 30, 1880.		10,000

D 6.

IMPROVEMENT OF HARBOR AT PORT CHESTER, NEW YORK.

There being no appropriation for this work, no operations were conducted during the year, except making a survey of Byram River, with view to the improvement of this portion of the harbor.

Collection-district, New York.
Nearest port of entry, New York.
Nearest light-house, Great Captain's Island.
Amount of revenue collected, $91,992,629.62.
Amount of commerce to be benefited by completion of this work ——.

ORIGINAL ESTIMATE.

Removing rocks and building breakwater	$96,632 00
Amount appropriated by act of Congress approved June 10, 1872	12,000 00

Money statement.

July 1, 1877, amount available	$2,200 00
July 1, 1878, amount expended during fiscal year	250 00
July 1, 1878, amount available	1,950 00
Amount (estimated) required for completion of existing project	84,632 00

D 7.

IMPROVEMENT OF HARBOR AT RONDOUT, NEW YORK.

The branch dike, 883 feet in length, under contract with H. V. Sloat Brother, was completed September 12, 1877.

Contract was made September 12, 1877, with Thomas Sturgeon, sr., for 950 feet of pile-dike on south side of the channel. The work was completed June 1, 1878, 893 feet 6 inches of dike having been completed.

The junction of the north and branch dikes being very much exposed to damage by steamers and tows striking against it when entering the harbor, authority was received to place a fender of pile-work around the junction of the two dikes, and to drive spring-piles along the face of the north dike and branch dike to mark their location at high-water.

This work was done by hired labor, and 64 spring-piles were driven, and fender-work for 200 feet along the face of the north dike and 125 feet along face of branch dike.

During the prevalence of high-water in the spring of 1878, a large schooner ran through the south dike, which was entirely covered, making a break completely through the dike of about 40 feet.

Under authority from the Chief of Engineers this was repaired by hired labor and open purchase, and a number of spring-piles were driven along the face of the dike to mark its locality during high-water.

This work has been under the superintendence of Capt. James Mercur, Corps of Engineers, since August 20, 1877.

Collection-district, New York.
Nearest port of entry, New York.
Amount of revenue collected, $91,992,629.62.
Amount of commerce and navigation benefited by the completion of this work ——.

C 7.

IMPROVEMENT OF SOUTHPORT HARBOR, CONNECTICUT.

With the appropriation of $5,000 made by act of Congress approved August 14, 1876, the following work has been done at this harbor:

An agreement was entered into with Mr. J. H. Fenner, of Albany, N. Y., under which a channel 60 feet wide and 4 feet deep at mean low-water was dredged from the outer beacon to above the end of the breakwater. The vacant spaces between the walls of the dike were filled with a portion of the dredged material, and the remainder deposited in deep water outside the harbor.

Seventeen cents per cubic yard was paid for the latter work, and 37 cents for the former. Under this agreement, about 15,000 cubic yards of material have been removed, making a channel 60 feet in width and 4 feet deep at mean low-water. The repairs upon the dike by filling void spaces between the walls with material from the channel have been completed.

It being desirable to make the width of the dredged channel 100 feet, an additional sum of $5,000 is needed for this purpose, which could be profitably expended during the next fiscal year.

Following are the amounts appropriated for this harbor since 1838:

March 3, 1875	$5,000 00
August 4, 1876	5,000 00
	10,000 00

Southport is in the Fairfield collection district, of which Bridgeport is the port of entry. The amount of revenue collected there for the fiscal year ending June 30, 1878, was $4,561.69. The nearest light-house is on Penfield Reef, 3¼ miles from the harbor. Fort Hale, New Haven Harbor, the nearest work of defense, is 24 miles distant.

COMMERCIAL STATISTICS.

The following statistics relating to the commercial business of this port have been furnished by J. H. Perry, esq.:

Total number of vessels of all classes entered and cleared during the fiscal year ending June 30, 1878	200
Total tonnage	2,500
Estimated value of cargoes received	$110,000
Estimated value of cargoes shipped	$125,000
Number of vessels of all classes entering the harbor for refuge during the year	100

Money statement.

July 1, 1877, amount available		$5,063 93
July 1, 1878, amount expended during fiscal year	$3,185 19	
July 1, 1878, outstanding liabilities	1,226 05	
		4,411 24
July 1, 1878, amount available		652 69
Amount (estimated) required for completion of existing project		5,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		5,000 00

C 8.

ıENT OF PORT JEFFERSON HARBOR, LONG ISLAND, NEW YORK.

ɔropriation of $6,000, made by act of Congress approved August was applied to repairing the east jetty and the excavation of a gh the bar, in about equal proportions.

ɔrk upon the breakwater was executed under contract with ngerson and Molthrop, and consisted in adding stone to its ıgth, widening, strengthening, and raising the structure, with more thoroughly arresting the flow of sand into the channel direction of Mount Misery.

terval between the shore end of the jetty and the plank fence, which large quantities of sand had been driven by easterly ras securely closed by a stone extension of the jetty, and the tinued still farther inland. The jetty at its sea end was curved rt distance.

ɔne-work was well executed, and has withstood the severe win- with trifling injury. A portion of the plank fence, at its extreme nd above ordinary high-water, was injured during the winter. is considered that the posts of this fence are 8 inches by 8 inches, laced 4 feet in the ground, some idea may be had of the action er of the waves during the concurrence of a severe easterly d an abnormally high tide.

t through the bar was successfully accomplished. The difficul- ehended in dredging on this bar rendered contractors reluctant ıpon the work, and it was therefore decided to make the experi- h hired machinery. A satisfactory arrangement was entered Mr. M. F. Brainard for the use of his dredge, tug, and scows, ɔer hour, working time. As was anticipated, the chief difficulty red was the tide, which ebbs and flows with such strength that ; ordinarily used for holding the dredge in place were inadequate, chors and hawsers being required in addition. The cut when d was 1,300 feet in length, 25 feet in width, and 8 feet deep at mean r, where the least depth was previously but 2½ feet. The rry-boat is now able to cross at all stages of the tide. It is that the outer end of this cut became partially filled during a ɒrm last winter, but afterward cleared itself by the action of the

the jetties have been carried to their proposed length, 9 feet of ere is every reason to believe that a channel 8 feet in depth will ıstaining, and although the material of this bar is very heavy, rgely composed of coarse gravel mixed with stones of several veight, it is not impossible that the present cut will increase in the augmented force of the current, due to the contraction of ıry.

ans for the improvement of this harbor, now in process of execu- template the extension of the jetties to 9 feet of water, and, if cessary, to excavate by dredging a channel 100 feet wide through The appropriation of $10,000 made at the last session of Con- ll be expended in accordance with these plans.

ıoped, however, that a large part of this excavation will be done ıction of the tidal current when concentrated and strengthened ɔompletion of the jetties.

Reef of rocks covered with sand, near Whitehead's Dock, 11,509 cubic yards	$497,188 80
Middle ground, 55,555 cubic yards, at 35 cents	19,444 25
Stakes, 15,528 cubic yards, at 35 cents	5,434 80
Dike, 11,400 feet long, at $13.50 per running foot	153,900 00
Contingencies, 15 per cent. of the above	273,086 35
	2,093,662 05

Money statement.

Amount appropriated by act approved June 18, 1878	$200,000 00
July 1, 1878, amount available	200,000 00
Amount (estimated) required for completion of existing project	1,893,662 05
Amount that can be profitably expended in fiscal year ending June 30, 1880.	200,000 00

D 10.

IMPROVEMENT OF ECHO HARBOR, NEW ROCHELLE, NEW YORK.

Under the appropriation of June 18, 1878, of $10,000, it is proposed to advertise for proposals for the removal of the rock known as "Start Rock" to a depth of 7 feet below mean low-water.

This work is in the collection district of New York.
Nearest port of entry, New York.
Nearest light-house, Execution Rock.
Amount of duties collected for year ending June 30, 1878, $91,992,629.62.
Amount of commerce to be benefited by the completion of this work is estimated at $1,000,000 per year.

ESTIMATE OF COST OF IMPROVING ECHO HARBOR, NEW ROCHELLE, NEW YORK, BY THE REMOVAL OF "SHEEPSHEAD ROCK" TO A DEPTH OF 9 FEET BELOW MEAN LOW-WATER, AND OF "START ROCK" TO A DEPTH OF 7 FEET BELOW MEAN LOW-WATER.

Sheepshead Rock, 872.5 cubic yards, above the 9-foot curve of 905 square feet area, at $24.30 per cubic yard	$21,201 75
Start Rock, 370 cubic yards, spread over an area of 264 square yards within the 6-foot curve, at $34.25 per cubic yard	12,672 50
Contingencies, 15 per cent. of the above	5,081 13
Total	38,955 38

AMOUNT APPROPRIATED.

By act of Congress approved June 18, 1878	$10,000 00

Money statement.

Amount appropriated by act approved June 18, 1878	$10,000 00
July 1, 1878, amount available	10,000 00
Amount (estimated) required for completion of existing project	28,955 38
Amount that can be profitably expended in fiscal year ending June 30, 1880.	10,000 00

D 11.

IMPROVEMENT OF HARBOR AT PLATTSBURGH, NEW YORK.

The empty cells in the breakwater have been refilled with stone. The bar, extending easterly from the face of the south wharf, has been removed. The water from this point, extending in a northerly direction to and along the face and approaches of the northern line of wharves, has been increased to a depth of 8 feet and upward, and proving a great

enefit to commerce and navigation. Ten hundred and seventy-three ubic yards of silt, sand, clay, and stone have been dredged and removed from the harbor, and 525 cubic yards of rubble-stone applied to he repair of the breakwater.

Deposits are collected along the wharf front and also between the wharves and the breakwater, diminishing, in consequence, the importance o commerce and navigation of this structure. These shoals appear to gather in bulk sufficient to obstruct navigation at intervals of six or seven years, when dredging becomes necessary.

During the present fiscal year about $3,400 have been applied to the obstructions nearest to the wharves, and it is estimated that $5,000 more will be required to remove those nearest the breakwater.

The deposits causing thus an expenditure of nearly $9,000 in seven years come from two sources, viz, by drift from waves beating along the face of the United States reservation; and, second, from the deposits of silt, sawdust, &c., brought down by the currents of the Saranac.

Upon the plan herewith sent two lines of crib dike are sketched—the one extended to form a pocket south of the extreme south wharf for the collection of the wash along the shore of the reservation, the other to change the direction of the discharge of the river, and to locate its deposits at a point more distant from the breakwater.

The estimated cost of these breakwaters is between $45,000 and $50,000. The annual interest upon this cost would somewhat exceed the annual expense of dredging, and hence it is recommended that appropriations for dredging be made from time to time.

Plattsburgh is in the collection-district of Champlain, and is a port of entry.
Nearest fort, Fort Montgomery, Rouse's Point, New York.
Amount of revenue collected at this port during the last fiscal year ———.
Commerce to be benefited by the completion of this improvement ———.

ESTIMATE OF SEPTEMBER 30, 1870.

Extension of breakwater, 400 feet	$40,000 00
Revetment	7,000 00
Dredging	16,000 00
Contingencies	2,000 00
	65,000 00

AMOUNT APPROPRIATED.

By act of Congress approved July 11, 1870	$10,000 00
By act of Congress approved March 3, 1871	15,000 00
By act of Congress approved June 10, 1872	10,000 00
By act of Congress approved March 3, 1873	10,000 00
By act of Congress approved June 23, 1874	5,000 00
	50,000 00
Amount expended	49,019 51

Money statement.

July 1, 1877, amount available	$4,941 52
July 1, 1878, amount expended during fiscal year	3,961 03
July 1, 1878, amount available	980 49
Amount (estimated) required for dredging	5,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.	5,000 00

D 12.

IMPROVEMENT OF HARBOR AT BURLINGTON, VERMONT.

The 240 linear feet of the southern end of the breakwater remai unfinished last year has been completed.

A crib 28 feet in length and of the required height for filling the " near the southern end, has been constructed, sunk in position, and with stone. The broken timbers along the water-line of the exterio of the old breakwater, for nearly 1,150 running feet, have been repl by the substitution of new material.

The work of repairing the 200-feet rent near the northern end, b removal of the *débris* and reconstruction of the superstructure has completed, and the exterior face of this part of the breakwater, tog with the 1,150 running feet of the old and 270 feet of the new, nea southern extremity, has been resheathed with 3-inch pine plank.

Several cells in the old breakwater, whose floors had failed (or g way), have been repaired and filled with stone, and about 390 yards of rubble-stone have been applied to the riprapping of diff parts of the work.

Under the appropriation of June 18, 1878, of $20,000, it is propos continue the extension of the work in a northwesterly direction.

This work is in the collection district of Vermont.
Nearest port of entry, Burlington.
Fort Montgomery is the nearest fort.
Nearest light-house, Juniper Island.
Beacon lights are also maintained upon either end of the breakwater in this h
Amount of revenue collected at this port during the fiscal year, $88,684.

ORIGINAL ESTIMATE.

For 2,000 feet of breakwater extension, in a northwest direction, as recomm in my report for year ending June 30, 1874, $340,000.

AMOUNTS SINCE APPROPRIATED.

By act of Congress approved March 3, 1875	$25,0
By act of Congress approved August 14, 1876	20,0
By act of Congress approved June 18, 1878	20,0
	65,0
Amount expended	42,2

Money statement.

July 1, 1877, amount available	$15,477 15	
Amount appropriated by act approved June 18, 1878	20,000 00	
		$35,4
July 1, 1878, amount expended during fiscal year		12,7
July 1, 1878, amount available		22,7
Amount (estimated) required for completion of existing project		275,0
Amount that can be profitably expended in fiscal year ending June 30, 1880		50,0

D 13.

IMPROVEMENT OF HARBOR AT SWANTON, VERMONT.

Mr. D. White, assistant engineer, submits the following report:

Under the appropriation of August 14, 1876, of $2,000, no work has been done, the amount being too small to permit the construction of a crib of sufficient size to maintain its stability.

This breakwater was seriously injured by ice-floes during the prevalence of a heavy northwesterly storm in the month of March last, the 69 linear feet last constructed was careened over to an angle of about 45°, and two courses of timber along the water-line of the interior face of the adjoining section were crushed and torn from their places, permitting a large quantity of the stone filling of the superstructure to drop out.

Under the appropriation of June 18, 1878, of $20,000, together with the preceding one of $2,000, it is proposed to repair the injuries inflicted on the breakwater by the ice-floes, and to continue the extension of the breakwater in a northwesterly direction by the construction of new work.

Swanton Harbor is in the collection district of Vermont.
Nearest port of entry, Alburgh, Vt.
Fort Montgomery is the nearest fort.
Nearest light-house, Windmill Point.
The amount of commerce to be benefited by this improvement ———.

ORIGINAL ESTIMATE.

For 1,900 linear feet of breakwater	$272,160 00

AMOUNTS APPROPRIATED.

By act of Congress approved March 3, 1873	$15,000 00
By act of Congress approved June 23, 1874	8,000 00
By act of Congress approved March 3, 1875	10,000 00
By act of Congress approved August 14, 1876	2,000 00
By act of Congress approved June 18, 1878	20,000 00
	55,000 00
Amount expended	32,399 50

Money statement.

July 1, 1877, amount available	$2,610 65	
Amount appropriated by act approved June 18, 1878	20,000 00	
		$22,610 65
July 1, 1878, amount expended during fiscal year		10 15
July 1, 1878, amount available		22,600 50
Amount (estimated) required for completion of existing project		217,160 00
Amount that can be profitably expended in fiscal year ending June 30, 1880		20,000 00

D 14.

IMPROVEMENT OF OTTER CREEK, VERMONT.

For want of funds, work on this improvement has been suspended since August, 1875.

Under the appropriation of June 18, 1878, it is proposed to resume

operations on the improvement of the channel and the navigation of Vergennes Basin.

Vergennes, Vt., is in the collection district of Vermont.
Nearest port of entry, Burlington, Vt.
Nearest fort, Fort Montgomery, Rouse's Point, N. Y.
Amount of commerce to be benefited by this improvement ———.

ORIGINAL ESTIMATE.

Dredging dikes and fascine work	$57,646 00
Removing trees	500 00
	58,146 00

AMOUNTS APPROPRIATED.

By act of Congress approved June 10, 1872	$10,000 00
By act of Congress approved March 13, 1875	5,000 00
By act of Congress approved June 18, 1878	8,000 00
	23,000 00
Amount expended	14,949 16

Money statement.

July 1, 1877, amount available	$55 84	
Amount appropriated by act approved June 18, 1878	8,000 00	
		$8,055 84
July 1, 1878, amount expended during fiscal year		5 00
July 1, 1878, amount available		8,050 84
Amount (estimated) required for completion of existing project		35,146 00
Amount that can be profitably expended in fiscal year ending June 30, 1880		20,000 00

D 15.

EXAMINATION OF THE COAST OF LONG ISLAND BETWEEN ROCKAWAY INLET AND CONEY ISLAND.

UNITED STATES ENGINEER OFFICE,
New York, March 8, 1878.

GENERAL: I have respectfully to furnish the following report in pursuance of a resolution of the House of Representatives of January 29, 1878:

Resolved, That the Secretary of War be, and he hereby is, directed to communicate to the House as soon as practicable, what improvements, if any, are demanded by the interests of commerce along the south coast of Long Island, New York, between Rockaway Inlet and Coney Island Point, based on examinations and surveys already made by the Coast Survey or other departments of the government.

The scope of this resolution is broad, and evidently includes a discussion of the propriety of erecting breakwaters as well as improving the entrances of such inlets as may be found along the section of coast specified.

BREAKWATERS.

The coasts of Long Island and of New Jersey meeting at the bar at Sandy Hook, limit a water area which is exposed to the severest gales (from the northeast around to the south) which desolate this coast. The line specified under the resolution is but 5½ miles in length, from

the point of Coney Island to Rockaway Inlet, and every part of it being in the immediate neighborhood of the entrance to the harbor of New York, the question would naturally arise, what necessity under such circumstances could there be for the construction of a breakwater? Obviously, only under the contingency, which would belong to a very severe storm, of the waves breaking on the bar and thus preventing the passage of the tempest-tossed vessels to the natural harbor within. The position for a breakwater under this aspect of things along the portion of the coast under consideration, would be west of Rockaway Inlet in 5 fathoms of water—the line facing the southeast. This line would, if prolonged, intersect at short distances the shore of Long Island and Sandy Hook, and would thus have its flanks protected from dangerous seas. Rockaway Inlet, however, is continually advancing westward, accompanied by immense shoals of moving sand, which are gradually restricting and may finally obliterate the deep-water area suitable for a breakwater and now lying between the inlet and Coney Island Point, rendering it necessary thereby to fix the location in deeper water and in a more exposed position.

No money was granted by Congress for the examination of the localities specified in the resolution; and, for the purposes of this report, recourse has been had to charts made by the Coast Survey in 1855–'56 and 1877. There is a large amount of specific information connected with the question of the establishment of a breakwater on this coast which would not naturally be found in the mere results of surveys, and hence, beyond pointing out the obvious risks of the shoals hereafter interfering with the effects of a breakwater placed in the position indicated, it is not expedient under existing circumstances to attempt to be more exact in predicting results.

IMPROVING THE INLETS.

There are two inlets within the space considered, into Jamaica Bay and into Sheepshead Bay. The former, called Rockaway Inlet, is by far the most considerable, and is besides the only one of which surveys have been published.

The Coast Survey of 1855–'56 shows a depth over the bar of 9 feet at mean low-water, and the recent examination in 1877 shows an improved depth of 15 feet. The first survey makes the channel from the inlet to the bar much curved, presenting its concavity to the eastward. The last survey shows a straight channel, its direction being a little to the west of south.

It is quite likely, from this information as well as from general principles, that the straight channel, under like circumstances, would always correspond to the greatest depth over the bar, though a more lengthened course of observations would be needed to demonstrate absolutely this conclusion, and what is more important, to point out what *direction* given to the channel would correspond to the greatest possible depth on the bar.

This inlet with the shoals attached has moved westward from 1856 to 1877, a period of twenty-one years, a distance of 4,620 feet, being at the rate of 220 feet per year. An attempt to arrest this movement by artificial works would be successful only after enormous expenditures, and would inevitably result in the obliteration of the inlet itself. The sole improvement, therefore, of which this entrance is susceptible consists in giving the proper direction to its channel, and this can be done by constructing a series of groins upon the eastern shoal to encroach upon

the eastern edge of the channel at those places where it may be found necessary to remedy or modify a curvature in the course of the channel. It is obvious that these constructions will not interfere with the free movement westward of the shoals and inlet.

The groins should be of little height and submerged wherever practicable, and be constructed of gabions as recommended and tested by Major Howell, Corps of Engineers, at Galveston.

The cost per running foot of these constructions would at most be $20, and this high rate is assumed because it would be at infrequent and irregular intervals only that the work would go on.

The depth over the bar being now 15 feet, no improvement at present appears to be needed.

The south coast of Long Island, from Coney Island to and beyond Rockaway Inlet, is the subject of a present and apparently permanent development. As a summer resort it numbers its visitors already by hundreds of thousands, and the necessary establishments for their accommodation are steadily and largely on the increase.

The commerce by vessels is now principally confined to the summer season.

The qualities of the locality as a convenient and healthful summer resort, and the proximity and extension towards the coast of the large city of Brooklyn, will probably lead to a large permanent population, for the supply of which the water expanse of Jamaica Bay and the preservation of its inlet in good condition will be important items. From the nature of the case there can be no definite statistics of commerce and navigation furnished for this section of the coast.

According to the present rate of advance westward, Rockaway Inlet in about sixty years will have moved with its shoals and have become mixed with the passes and shoals of New York Harbor lying between Sandy Hook and Coney Island. When this shall happen, the inlet will be practically closed.

But there is no certainty that the present rate of advance will be maintained, because the information is not available to determine whether the currents from New York Bay may not seriously check and modify such movement.

Whatever may be its duration, it is but fair to grant the strong probability that sooner or later the inlet must close for commercial purposes, and hence the scheme of improvement adopted should be inexpensive, like that recommended in a former part of this report.

CONCLUSIONS.

1. A breakwater along this section of the coast will be needed only when the waves break on the bar at Sandy Hook, and make a run into New York Bay dangerous or impossible.

2. The advance of the inlet and shoals westward will probably interfere with the future use of the breakwater, unless the position of this structure be advanced into deep water sufficiently far to avoid such result.

3. The channel leading into Rockaway Inlet is now straight, and maintains the considerable depth of 15 feet over the bar, which is amply sufficient for all present and future commercial purposes.

4. Although the motion westward of the inlet and its channel cannot be prevented, nevertheless such direction and shape to this channel can be preserved as may be found by experience to accompany and belong to the greatest draught over its bar.

5. There is a strong probability that sooner or later the inlet will close for commercial purposes, and hence the mode of improvement should be inexpensive, as recommended in the report.

6. The information to be obtained and bearing upon the subjects considered, although indicative of certain general results, is altogether insufficient for a complete solution of the questions formally presented and of those arising from a consideration of the subject, and further examinations intelligently directed may largely modify certain conclusions now considered altogether probable.

Respectfully submitted.

JOHN NEWTON,
Lieut. Col. Engineers, Bvt. Maj. Gen.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

D 16.

EXAMINATION AT JUNCTION OF NEWTOWN CREEK AND EAST RIVER, NEW YORK.

UNITED STATES ENGINEER OFFICE,
New York, March 26, 1878.

GENERAL: I have the honor to acknowledge the receipt of a letter from the office of the Chief of Engineers of the 21st instant, communicating the following:

IN THE HOUSE OF REPRESENTATIVES,
March 20, 1878.

On motion of Mr. Covert:

Resolved, That the Secretary of War be requested to inform this House whether any deposits have occurred at the piers near the junction of Newtown Creek and the East River, in the State of New York, calculated to obstruct navigation, and if so, the probable cost of removing the same.

On February 8, last, I received, by indorsement, from the office of the Chief of Engineers, a communication upon the subject of the improvement of Newtown Creek, from Mr. H. S. Anable to the Hon. James W. Covert, M. C.

UNION COLLEGE LAND OFFICE,
Long Island City, December 10, 1877.

DEAR SIR: Herewith I send you map of the mouth of Newtown creek, showing water grant and dock lines. The docks on the north side of the creek, as well as the east side of the East River at this point, are all built and mostly occupied; and so is the most of it on the Brooklyn side of the creek.

At the mouth of this creek is a heavy sand bar which very seriously disturbs the commerce of the creek. Much money has already been expended by private individuals upon this bar, but the burden is too great and the benefit too general for private enterprise.

An appropriation of $30,000 judiciously expended in removing this bar would give 25 feet of water, and thus open Newtown Creek to the commerce of the world. Large quantities of refined oil is already shipped from this creek, which is taken in lighters outside of the bar.

I know of no expenditure of money which would be more national in its character than the improvement of this portion of the harbor of New York.

Last winter, late in the session, Mr. A. M. Bliss, of Brooklyn, introduced a bill for this purpose. He has spent the most of his life on the banks of this creek, and knows all about its needs. Please consult him. Hon. C. N. Potter understands this case, and will give you any needed assistance. Please mention to him the substance of this letter. He will be a great power in this matter.

Should it be necessary, I will, at the proper time, go before the committee having the bill in charge with any further needed information. I hope you will have the bill introduced before the recess.

Respectfully yours,

H. S. ANABLE.

Hon. JAMES W. COVERT.

FEBRUARY 2, 1878.

MY DEAR SIR: I beg most respectfully to call your attention to the within communication, and to solicit your kindly offices in having a preliminary survey of the locality in question, to the end that the improvement referred to may be made.

With great regard, your obedient servant,

JAMES W. COVERT,
Representative First New York District.

Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

[Second indorsement.]

OFFICE OF THE CHIEF OF ENGINEERS,
February 7, 1878.

Respectfully referred to Lieut. Col. John Newton, Corps of Engineers, for report.
By command of Brigadier General Humphreys.

JOHN G. PARKE,
Major of Engineers.

Notwithstanding the fact that no funds were granted with which to conduct an examination, certain information, not complete, however, had been collected upon which to base an opinion in reply to the above communication at the time when the notice of the Congressional resolution was communicated to this office.

As neither demand for a report supposed that money for examinations of the creek and for collecting information was required, it is not to be expected that this report should contain any matter that has not been previously known.

A comparison of present soundings with those of 1856–'57, shows a general as well as considerable silting up of the creek, and the inference is that this diminution of depth is due to reclaiming lands under water, and thus diminishing the tidal area.

The bridge over the creek at the foot of Vernon avenue is a great obstruction to the flow of the tides, and should be essentially modified or removed; and it is reported that there are two other bridges above this which likewise interfere with the tides.

The character of the bottom, both up the creek and on the bar, was found in most places to be mud, in some places so soft that the sounding lead sunk 2 feet into it.

The current-observations show that the velocities of the ebb and flood in mouth of the creek are too small to be available in preserving depths once dredged.

In reply to the resolution of Congress, it must be stated that deposits have occurred at the piers near the junction of Newtown Creek and the East River, and that the probable cost of removal to a depth of 14 feet at mean low-water would be $2,000.

This shoal has been dredged at some time past, and the present depth is nearly uniform from the junction of the creek with the East River as far up as the bridge at Vernon avenue.

Dredging unless repeated will be of no avail in keeping open the channel even to a depth of 14 feet at mean low-water, and if the projected lines of filling be adhered to, the normal depth of the entrance and the creek will be far less than 14 feet.

The city of Brooklyn contains within its limits three channels which

te into the heart of the city, and are of great utility in affording
g places at convenient points for heavy goods, and thereby dimin-
the amount of truckage and expense required for their distribu-
Two of these, the Gowanus and the Wallabout Canals, are com-
or nearly bulkheaded, and may be regarded as finished; the
Bushwick Creek, is very little better than a swamp, and the in-
has not been developed either to canalize it, like the former two,
ll it up for conversion into building lots. Newtown creek, situ-
etween Brooklyn and Long Island City, not only subserves the
e of a communication to the interior of these cities, and thus aids
cheap distribution of goods, but it is claimed, likewise, as a pro-
annel for vessels of heavy draught to load at the wharves upon
ks.

tendency always is to contract the width of channels penetrating
city, and to fill in the lowlands on their margin which overflow
ne tides, for various reasons, some of which are of paramount im-
ce—as, for instance, to establish convenient sites for business, man-
res, &c., as well as to adhere to a certain design adopted for the
f the city. The value of the land on the margin becomes also so
that it is considered more profitable to redeem it from the water
o secure the preservation of the original depth of the channel by
ervation of suitable width and space for a tidal basin. The stream
lually encroached upon, its tidal basins converted into building
nd the process of canalization progresses, until a narrow channel
en parallel bulkhead walls is all that remains of its former propor-
In the mean time the depths have decreased to an alarming ex-

here is but one resource, and that is to dredge and to continue
ng.

o this time such has been the effect of the encroachments upon
l of Newtown creek. The current has so slackened that it is inca-
of maintaining a depth of 13 feet at mean low-water without
ngs repeated from time to time, and if the process of reclaiming
om the channel be continued upon the scale in which it has com-
d, the current will be made entirely inoperative for scouring. The
aid down by the commission of 1856–'57, contract too much the
, and if followed will entirely destroy its properties as a self-main-
g channel.

current, even as it at present exists, is not sufficient to clear off
t deposits which form upon the harder bottom.

want of money to prosecute a suitable survey and examination of
ole length of the creek forbids any decision as to the value, after
as already been done, of preventing further encroachments and a
r deterioration in depth.

s not my province to discuss the propriety of appropriations for
nprovement, but it is my duty to present the principal engineering

D 17.

EXAMINATION OF FLUSHING BAY, NEW YORK.

NEW YORK, *March* 28, 1878.

GENERAL: I have respectfully to acknowledge the receipt of communication of the 26th ultimo, from the office of the Chief of Engineers, conveying the following:

IN THE HOUSE OF REPRESENTATIVES,
February 25, 1878.

On motion of Mr. Covert,

Resolved, That the Secretary of War be, and he is hereby, directed to communicate to this House as soon as practicable what improvements, if any, are demanded by public interests or by the interests of commerce, for the improvement of Flushing Bay, in the State of New York, and the navigation thereof, together with the estimated cost of such improvements.

As no money has been granted to defray the expenses of a survey or examination of the locality, it is to be presumed that this report was intended to embody information which would be available without cost to the government.

Inclosed will be found copies of letters from Messrs. E. Platt Stratton, William B. Draper, and J. Milnor Peck, prominent citizens of the locality, which recapitulate the points constituting the alleged necessity for improvement of the navigation of Flushing Bay.

From these communications it appears that the number of inhabitants to be benefited is about 30,000, and that visits to New York must be paid by rail, as the draught of water in Flushing Bay has so diminished that communication by boat can be had at only or about high-water.

Prior to 1863 fully one-half of the communication was effected by two steamboats making each six trips daily.

In 1861 there was a depth of five feet at average low-water to Flushing; but at present this draught has decreased—exactly how much, the accounts differ.

To decide upon the feasibility and cost of an improvement of navigation a survey and examination would be necessary, as the sole information on these points now available comes from the Coast Survey soundings of 1855 (a tracing of which, embracing Flushing Bay, is sent herewith), of a date prior to the alleged diminution of depth in the bay.

It is to be presumed that the causes which have concurred in causing a deposit in the bay since 1863 will continue, and, if so, that a remedy to this shoaling, by means of dredging alone, must be repeated from time to time, depending for its frequency upon the rate of deposit.

The estimate for dredging, under present knowledge of the locality, must be conjectural, and is given under the assumption that it is required to make an excavation of the bottom one mile long, one hundred feet wide, and three feet deep, which would cost, supposing the material throughout to be of ordinary hardness, $15,000.

Respectfully submitted.

JOHN NEWTON,
Lieut. Col. of Engineers, Bvt. Maj.-Gen.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

APPENDIX E.

;AL REPORT OF COLONEL J. N. MACOMB, CORPS OF ;INEERS, FOR THE FISCAL YEAR ENDING JUNE 30, ;.

UNITED STATES ENGINEER OFFICE,
Philadelphia, Pa., July 10, 1878.

;ERAL: I have the honor to submit herewith the annual reports :he several works in my charge, for the fiscal year ending on the f June, 1878, together with the estimates for the completion or r prosecution of these works for the fiscal year ending 30th of 1880.

submitting these reports I would state that I took charge of this on the 1st of December, 1877, in pursuance of Special Orders No. ated Headquarters of the Army, 31st of October, 1877. The works n the charge of Lieut. Col. J. D. Kurtz, Corps of Engineers, U. S. A., he time of his death, which occurred on the 16th of October, 1877. William Ludlow, Corps of Engineers, U. S. A., who had been the nt of Lieutenant-Colonel Kurtz, was assigned temporarily to the e of the works, by Special Orders from the headquarters of the of Engineers, under date of 29th of October, 1877, and so ned until I entered fully upon the duties of this station in the part of January, 1878.

field-work having generally ceased before my arrival here, I called Captain Ludlow and the assistant engineers engaged upon the during the past year to prepare the reports which I now beg to present, as giving the fullest information on the subject which n my power to give.

I remain, very respectfully, your most obedient servant,

J. N. MACOMB,
Colonel of Engineers.

g. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

E 1.

TRUCTION OF PIER IN DELAWARE BAY, NEAR LEWES, DELAWARE.

REPORT OF CAPTAIN WILLIAM LUDLOW, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Philadelphia, Pa., July 8, 1878.

ONEL: I have the honor to submit herewith my report of operations for the fiscal nding June 30, 1878, for constructing pier in Delaware Bay, near Lewes, Del. operations from the commencement of the working season to June 30, 1877, are in the Report of the Chief of Engineers for 1877, pp. 255 *et seq.*

ly in July a test was made of the weight-sustaining capacity of the large pile s (8¼ inches in diameter and 55 feet long) and of the gravel stratum in which their s rest. For this purpose pile No. 265, the center one of the seventy-fifth row, 1,575 rom shore, was selected as characteristic and convenient. The cross-braces con- ng it with the adjoining piles of the same row were allowed to remain attached, viate danger of flexure from possible inequality in distribution of load. It was

otherwise unsupported. A cradle of wood was framed and bolted securely to the c and the testing weights applied, consisting of 6 pile shafts, aggregating with the otl appendages about 63,100 pounds in weight. These were successively raised from t deck of the vessel that delivered them, and lowered upon the cradle, the operati being closely watched by means of a leveling instrument. The load was allowed remain on over night, and as no depression could be detected after sixteen hours trial the test was considered to have established the satisfactory character of the gra stratum and of the workmanship of the pile and screw.

In the case of all the piles driven during the season, although they would at int vals descend of their own weight, sometimes as much as 5 feet or 6 feet through t soft strata penetrated, they invariably brought up solidly when reaching the gra stratum, and nearly the full power of the engine was developed in gaining the last or 14 inches.

In putting in position the 30 piles which constitute the main feature of the seaso work, and in all the operations in connection therewith, the performance of the ap ratus was entirely satisfactory; the steam-engine mounted upon the derrick-platfo furnishing the motive power for all maneuvers.

The sliding shoes of yellow pine, built to replace the cast-iron brackets and whe under the center main timbers of the derrick, were found to answer their purpose mirably, and with a lubricator composed of a mixture of black-lead and tallow, derrick was moved forward when required with great smoothness and rapidity. Saturday, July 7, 4 piles, completing the seventy-sixth row, were screwed down in hours, including two trips to shore with the scow for the piles.

It was found that the material could be disposed of so much faster than the c tractors could furnish it, that it was determined on July 10 to suspend operations u the final delivery of the iron-work under contract. The last cargo was recei August 28. Previous to this date work recommenced upon necessary repairs and sirable improvements.

The labor of hauling the timbers, tools, chains, cordage, &c., from the shore to end of the pier, a distance of some 1,600 feet, had become onerous, and a push-car v constructed of 3 feet gauge, with light wheels and axles, and a frame 10 feet lo The 3-inch by 6-inch deck-plank laid longitudinally on the east side of the pier w utilized as rails. An important and advantageous modification was also made in t portion of the derrick rigging which is applied when raising the pile from its horizon position on the scow to a vertical one preparatory to lowering it in place. An ing ious coupling was devised by W. H. Scofield, the overseer, which obviated much of time in splicing "the runner"—a rope by which the engine-drum turns the capst head in screwing down the piles. Full detail drawings and description of the p fected apparatus and maneuvers are in preparation and will be furnished at the cl of the next season's operations.

By direction of the late Lieutenant-Colonel Kurtz, preparations were made for te ing the stability of the fifty-seventh row of piles, the third in the pier-head and 1, feet from shore. This row is the outermost of the 6½-inch piles, 33½ feet long, a stands near a point where the stratum in which the screws lie changes its charac and sustaining power. In 1873, the center pile of this row had been depressed 2 inch and the adjacent ones ½ inch and ¾ inch respectively, under a calculated weight about 42,000 pounds, when fully braced crosswise and to the rear. Colonel Kurtz c sidered it desirable to further test its endurance.

The account of this test, with the results, is given in my report of September 1877, from which the following extracts are taken:

* * * * * * *

"In order to make the test, the cross-braces throughout the row were disconnect Three longitudinal braces were left on each of the outer piles and one on the cent one, to guard against possible accident from the superimposed weight proving t great and occasioning excessive subsidence. Nos. 2 and 4, upon which the weig were to be placed, were entirely freed. The deck-planking was taken up, the remai der of the superstructure being undisturbed. Blocks were placed over Nos. 2 and directly on the girders and the intersecting 9-inch by 9-inch cross-beams. Strips wood were attached to each pile, and a staging put up under the pier at a short d tance for level observations."

* * * * * * *

Under these circumstances the weights were applied, and the results noted by t level. Six piles, weighing 62,400 pounds, were rolled on and permitted to remain ov night. Five others were added next morning, making 11 in all, weighing 114,4 pounds. The subsidence, which began at once and gradually increased, was, with t ultimate load, 1¾ inches for No. 2, 2¼ inches for No. 4, and ⅞ inch for No. 3, the cent one. The outer piles were but slightly affected.

The conclusions reached from the test were as follows:

* * * * * * *

57th row possesses less bearing capacity than it should. The 6¼-inch piles
ly large, and will bring this bay fully up to the average strength of the pier,
up, lengthened, and redriven to the gravel stratum. The expense of doing
stimated at $2,000.
will admit of all the present material being used again.

* * * * * * *

h the 57th row resting solidly upon the gravel stratum, no apprehensions need
tained as to the entirely satisfactory stability of the 56th row."

* * * * * * *

se views Colonel Kurtz concurred, and the project for lengthening and redriv-
57th row is included in the estimate for next season's operations.
g much of September the weather proved unfavorable, and a heavy gale oc-
n the 8th.
ptember 10, 2 piles of the 77th row were driven, and on the 12th the remain-

lings were made under the 57th row by means of a 6-inch auger attached to a
od, and the relative resistance of the strata pierced calculated from the force
l to turn the screw. The depths to the gravel were carefully noted, in view
roposed lengthening of these piles.
mber 24, 4 piles were driven, and the remaining one of the 78th row on the
A dynamometer curve was obtained for the pile (No. 280), affording a measure
sistance at the various depths. An accident to the capstan-wheel broke 3 of
, and occasioned a loss of 1½ hours' time, or the whole row would have been
n on the 24th.
e 28th, the five piles of the 79th and final row of the season's work were screwed
The time consumed in this work was 10 hours and 53 minutes, which included
shore with the scow and loading the last two piles. The cams of the capstan-
y means of which the screwing motion is imparted to the pile, from long and
vear had become much flattened, and occasioned a delay of over 2 hours from
on the piles. The actual working time during which the 5 piles were put in
was less than 9 hours.
aterial for the season's operations having been exhausted, preparations were
close.
racing of the outer rows was completed, and the 5 outermost longitudinal
were lowered to the bed of the harbor, after the screw-threads had been care-
rapped with hemp and tallow. The derrick, engine, and other appliances
smantled, and the loose parts stored. The caps of the two outer rows of piles
nnected by timbers securely bolted on, to strengthen them against possible
of ice or collision with vessels.
er 5, a heavy gale did great damage to the shipping in the harbor.
er 15, the property was put in charge of the overseer as keeper until operations
be resumed.
llowing was the condition of the pier at the end of the season. The 30 piles
lace included the 79th row, 1,559 feet from the abutment, and extended the
feet:

	Feet.
s, 12 inches by 12 inches, extended to	1,554
s, 12 inches by 12 inches, extended to	1,533
ists, 4 inches by 9 inches, extended to	1,533
oists, 4 inches by 4 inches, extended to	1,512
g, west side, extended to	1,449
g, east side, extended to	1,407

perstructure of the pier was not pushed as far as it might have been, for the
hat it is proposed to suggest considerable modifications in the plan of construc-
the pier-head, in order to adapt it fully to its intended uses.
onnection between the continuous 12-inch by 12-inch girders was changed from
to a butt-joint over the 72d row of piles, 1,512 feet from abutment.
oped that the existing appliances will be able to perform another season's
ut apprehension is felt that such may not be the case., The derrick, in especial,
pensive structure, has done faithful service, and stood exposed to the weather
s construction and during protracted suspensions of work, suffering more injury
ne than use.
ld it break down, the small appropriation available would be seriously encroached
replace it.
impossible to avoid expressing regret that the full amount ($70,000) asked for
rk was not appropriated, that it might be completed during the coming season,
over to the public for use, and the estimates relieved of farther expense for its
nance.

The original estimated cost of the pier was		$387,419 67
Which was increased on account of the advance in price of iron and labor and the operations of the 8-hour law by		24,000 00
		411,419 67
Owing to the decreased price of iron and use of wood instead of iron in the fender-system, the estimate was reduced by		55,819 67
		355,600 00
Owing to the reduced appropriation recently made, being only two-fifths of the amount asked for completing this work, it is deemed necessary to further increase the amended estimate by some		4,400 00
		360,000 00
Total amount appropriated to June 30, 1878		325,000 00
This brings up the amount necessary for completing the pier to the sum of.		35,000 00
Which is respectfully asked for the fiscal year ending June 30, 1880.		
Total amount expended to June 30, 1878		304,998 91

Money statement.

July 1, 1877, amount available	$20,821 63	
Amount appropriated by act approved June 18, 1878	20,000 00	
		$40,821 63
July 1, 1878, amount expended during the fiscal year		20,820 54
July 1, 1878, amount available		20,001 09
Amount (estimated) required for completion of existing project		35,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		35,000 00

Very respectfully, your obedient servant,

WM. LUDLOW,
Captain of Engineers.

Col J. N. MACOMB,
Corps of Engineers, U. S. A.

E 2.

IMPROVEMENT OF ICE HABBOR OF NEW CASTLE, DELAWARE.

REPORT OF MR. JOHN J. LEE, ASSISTANT ENGINEER.

ENGINEER OFFICE,
Fort Delaware, July 1, 1878.

COLONEL: I have the honor to submit the following report of operations in improving the ice-harbor at New Castle, Del., for the year ending June 30, 1878:

A portion, 110 feet in length, of the coal-wharf below the piers has been removed, in addition to that previously taken away, making 218 feet in all, and a substantial head has been built on the part now remaining. Although about 36 feet more in length would have to be removed in order to bring the wharf within the line established by the harbor commissioners of New Castle, I consider that what has already been done is entirely sufficient, and that it would be a useless expenditure on the part of the United States, after rebuilding a head where the wharf was cut off, to tear it down and go through the same operation again for the additional 36 feet.

The head of the wharf is now at low-water line, and is more than 50 feet inside of the wharf line recommended by the United States Coast Survey authorities after a careful examination. I see no advantage in any further removal.

The wooden crib-foundation for the last remaining ice-pier proposed for this harbor was completed in readiness for the stone superstructure in December last. It was protected from running ice as far as practicable, and, favored by the unusually mild winter, received no injury. It is proposed to apply the amount appropriated for the ensuing year in building up the stone-work as much as it will allow, probably about four courses, or 8 feet from the platform.

Next year it is proposed to complete this pier and to dredge out the accumulated sediment in the harbor, for which purposes an appropriation of $18,500 is asked.

New Castle is in the collection-district of Wilmington, Del., which is also the near-

est port of entry. Fort Delaware is the nearest fort and the Bulkhead Shoal range-light the nearest light-house.

Total estimated cost of improvement	$120,000 00
Total amount appropriated	101,500 00
Total amount expended	91,500 00

Money statement.

July 1, 1877, amount available	$14,418 27	
Amount appropriated by act approved June 18, 1878	10,000 00	
		$24,418 27
July 1, 1878, amount expended during fiscal year		14,418 27
July 1, 1878, amount available		10,000 00
Amount (estimated) required for completion of existing project		$18,500 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		18,500 00

Very respectfully, your obedient servant,

JNO. J. LEE,
Assistant Engineer.

Col. J. N. MACOMB.
Corps of Engineers, U. S. A.

E 3.

IMPROVEMENT OF HARBOR AT WILMINGTON, DELAWARE.

REPORT OF MR. THOMAS VALENTINE, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Philadelphia, Pa., July 9, 1878.

COLONEL: I have the honor to submit herewith my report of operations for the year ending June 30, 1878, for improving harbor at Wilmington, Del.

During the fiscal year ending June 30, 1878, operations for the improvement of this harbor have been directed to the removal of about 170 cubic yards of fast-rock from the south side of the channel just below Third street, and about 7,000 cubic yards of mud from the channel just above the Christiana Iron Company's wharf, thereby completing the work under contracts executed during the fiscal year ending June 30, 1877. In the removal of fast-rock, the excavation has been made so as to afford 13 feet depth of water at ordinary low tide, and in the removal of all other material a depth of 12 feet has been made.

The result of operations for improving this harbor during the past year has been to extend the increased width and depth of the channel that was under improvement at the close of the last fiscal year above the iron company's wharf, up stream to about opposite the mouth of the Brandywine Creek, and to give increased width and depth to the channel at the locality where fast-rock has been removed. This latter work, particularly, will prove of considerable benefit to the commerce of the port, as it has diminished the difficulties heretofore existing in approaching and passing the draw passage at Third street bridge.

By act of Congress approved June 18, 1878, $7,000 were appropriated for "improving harbor at Wilmington, Del."

It is proposed to expend this sum during the present season as specified below, after proposals have been received, as follows:

For the removal of about 12,000 cubic yards of mud in the continuation of the improvement of the channel of the river in the immediate vicinity of the buoy depot; removal of 12,000 cubic yards of mud from the channel opposite and just above the mouth of the Brandywine Creek; about 40 additional cubic yards of fast-rock from the south side of the channel just below Third-street bridge, and about 28 additional cubic yards of fast-rock from the south side of the channel just above Third-street bridge, completing the removal of obstructions at these localities.

Next season it is proposed to continue the improvement of the harbor along the south side of the channel from the Christiana Iron Company's wharf, up stream toward the mouth of Brandywine Creek; remove a point that protrudes into the channel on the south, just above the mouth of the Brandywine and along the north side of the channel from opposite the Lobdell Works, up stream to near Market street. This will

require the removal of about 56,000 cubic yards of material, and will require an appropriation of $13,000.00.

Wilmington is in the collection district of Delaware, and is a port of entry. The nearest light-house and fort are, respectively, Christiana Light and Fort Delaware.

The amount of revenue collected at Wilmington during the fiscal year ending June 30, 1878, is $23.474.40, and at Philadelphia, $6,969,203.17.

The original estimate for improving Wilmington Harbor, Delaware	$83,000 00
Total amount appropriated to June 30, 1878	70,000 00
Total amount expended to June 30, 1878	62,998 85

Money statement.

July 1, 1877, amount available	$12,513 81	
Amount appropriated by act approved June 18, 1878	7,000 00	
		$19,513 81
July 1, 1878, amount expended during fiscal year		12,512 66
July 1, 1878, amount available		7,001 15
Amount (estimated) required for completion of existing project		13,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		13,000 00

Very respectfully, your obedient servant,

THOS. VALENTINE,
Assistant Engineer.

Col. J. N. MACOMB,
Corps of Engineers, U. S. A.

E 4.

IMPROVEMENT OF HARBOR AT MARCUS HOOK, PENNSYLVANIA.

REPORT OF MR. THOMAS VALENTINE, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Philadelphia, Pa., July 9, 1878.

COLONEL: I have the honor to submit herewith my report of operations for the year ending June 30, 1878, for improving harbor at Marcus Hook, Pa.

During the fiscal year ending June 30, 1878, no material change has taken place at this harbor, the condition of the ice-piers being substantially the same as mentioned in last year's report.

At the outer ice-pier on the upper line a small expenditure of funds is required to reset a portion of the top course, which has been moved slightly on its bed, and one of the stone mooring-posts at the same pier which has, in consequence, been moved slightly from its original position. The two wooden landing-piers and bridges, used in connection with the detached piers, need repairs; the caps and about 3 courses of timber immediately below them; the girders and decks to bridges are much decayed, and the earth filling to the piers is washed off.

During the present season it is proposed to make all necessary repairs at this work, which can be done from the existing appropriation.

Money statement.

July 1, 1877, amount available	$6,342 91
July 1, 1878, amount expended during fiscal year	1,321 15
July 1, 1878, amount available	5,021 76

Very respectfully, your obedient servant,

THOS. VALENTINE,
Assistant Engineer.

Col. J. N. MACOMB,
Corps of Engineers, U. S. A.

E 5.

IMPROVEMENT OF ICE-HARBOR AT CHESTER, PENNSYLVANIA.

REPORT OF MR. THOMAS VALENTINE, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Philadelphia, Pa., July 9, 1878.

COLONEL: I have the honor to submit herewith my report of operations for the year nding June 30, 1878, for improving ice-harbor at Chester, Pa.

The ice-harbor at this place is limited in extent, covering an area of only about 00,000 square feet, formed by timber-piers extending into the Delaware River on the prolongation of Market street on the north and on the prolongation of Edgmont avenue on the south.

The ice-piers and the connecting bridges on the upper line are in good condition, the piers having received quite extensive repairs, and the two connecting bridges were entirely rebuilt during the latter part of the fiscal year ending June 30, 1877.

The lower line of ice-piers are much in need of repairs; the upper courses of timber are decayed and broken at the angles. The connecting bridge was deemed unsafe and has been removed.

By act of Congress approved June 18, 1878, $3,400 were appropriated for "improving ce-harbor at Chester, Pa."

It is proposed to expend this sum during the present season in making suitable repairs to the piers on the lower line, rebuild the bridge to connect with the outer pier, nd also make requisite repairs to side-walls and gravel filling to causeway leading om the fast land to the ice-piers.

Chester has become firmly established as a manufacturing point. One of the largest on-ship-building establishments in the United States is located here.

Chester is in the collection district of Philadelphia. The nearest port of entry, ght-house, and fort are, respectively, Philadelphia, Fort Mifflin Light, and Fort ifflin.

The amount of revenue collected at Philadelphia during the fiscal year ending June 0, 1878, was $6,969,203.17.

Money statement.

mount appropriated by act approved June 18, 1878	$3,400 00
ly 1, 1878, amount available	3,400 00

Very respectfully, your obedient servant,

THOS. VALENTINE,
Assistant Engineer.

Col. J. N. MACOMB,
Corps of Engineers, U. S. A.

E 6.

IMPROVEMENT OF SCHUYLKILL RIVER, PENNSYLVANIA.

REPORT OF MR. THOMAS VALENTINE, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Philadelphia, Pa., July 9, 1878.

OLONEL: I have the honor to submit herewith my report of operations for the year ing June 30, 1878, for improving Schuylkill River, Pennsylvania.

uring the past year operations for the improvement of this river have been directed xcavating along the channel of the river from its mouth upstream to opposite the th of the back channel, and along the channel in the immediate vicinity of Gib- Point. At the former locality the work of improvement has been carried forward ccordance with the modification of the original project as recommended in the al report in 1875, which was to increase the width of the channel to 300 feet, with pth of 24 feet at ordinary low tide. About 50,000 cubic yards of mud have been ved.

The result of operations for the improvement of the river near Gibson's Point was to make a cut on the east side of the channel, about 2,000 feet in length, and to complete an unfinished cut on the west side of the channel, so as to afford 20 feet depth of water at ordinary low tide. About 17,000 cubic yards of mud and coarse gravel have been removed.

By act approved June 18, 1878, $30,000 were appropriated "for improving Schuylkill River, Pennsylvania." It is proposed to apply this amount during the present season in widening and deepening the cut between the mouth and the back-channel outlet into the Schuylkill, it being a continuation of the improvement of this portion of the river in accordance with the revised project under which work commenced during the fiscal year ending June 30, 1877, with a view, ultimately, of affording a channel 300 feet in width and a depth of 24 feet at ordinary low tide; in the removal of a sand and mud shoal on the east side of the channel just below the grain-elevator piers, of which repeated complaints have been made at this office during the past year; in the removal of a narrow strip of gravelly material on the east side of the channel just above Penrose Ferry bridge, so as to make a uniform width of 150 feet to the channel at that locality; to excavate along the channel commencing at a point just above Point Breeze and advancing up stream, forming a connection with the new deep-water channel excavated of late years by the United States; complete the excavation for the new channel in the immediate vicinity of Gibson's Point, including the removal of about 100 cubic yards of rock from the channel directly opposite Gibson's wharf. These several proposed improvements, except at the first-named locality, are to be prosecuted with a view of affording a channel-way 150 feet in width and 20 feet in depth at ordinary low tide.

This will require the removal of 135,100 cubic yards of material, distributed as follows, viz: From the channel between the mouth and the point of outlet of back channel into the Schuylkill River, 90,000 cubic yards of mud; from east side of channel just below the grain-elevator piers, 10,000 cubic yards of sand and mud; just above Penrose Ferry bridge, 3,000 cubic yards of fine gravel; from the channel between Point Breeze and "Gibson's," 32,000 cubic yards of mud and coarse gravel; from the channel off "Gibson's," 100 cubic yards of rock.

It is proposed to continue the improvement of the river during the next fiscal year by removing from the channel between the mouth and Girard Point, 100,000 cubic yards of sand and mud, thereby completing the enlargement of the channel at that locality; by removing 20,000 cubic yards of coarse material from the channel of the river between Point Breeze and Gibson's Point; 300 cubic yards of rock from the channel off "Gibson's," and about 50,000 cubic yards of sand and gravel from the channel-way between "Gibson's" and Gray's Ferry bridge. The proposed work at the last-named locality to be executed with a view of affording 18 feet depth of water at ordinary low tide. This will require an appropriation of $50,000.

Notwithstanding the meagre appropriation made for the improvement of this river for some years past, satisfactory results have been obtained from the amount of work executed. Ships are now loaded to a draught of 20 feet and upward as far up river as Point Breeze.

During the year a decided improvement has been made in the navigation of this river by the rebuilding of Penrose Ferry bridge by the city of Philadelphia—a draw-bridge constructed of iron about 416 feet in length, resting on a pivot-pier, and when open affords two draw-passages of about 183 feet each.

The benefits to commerce by the improvement of this river embrace principally foreign trade in grain and petroleum, which is very extensive, and is increasing, particularly in the item of grain, as the following statement will show:

Number of vessels at Point Breeze from June 30, 1877, to June 30, 1878.

Ships.	Barks.	Barkentines.	Brigs.	Schooners.	Sloops.	Barges.	Total.
38	204	4	28	47	12	72	405

Amount of petroleum and its products shipped from Point Breeze between above dates.

Refined.	Crude.	Benzine.	Total.
Barrels. 618,274	*Barrels.* 119,525	*Barrels.* 47,397	*Barrels.* 785,196

Number of vessels at and shipments of grain from Girard Point Elevator, from June 30, 1877, to June 30, 1878.

Steamers.	Ships.	Barks.	Brigs.	Schooners and barges.	Total.	Total bushels.
43	40	227	15	61	386	12,258,141

Number of vessels, and estimated shipments of petroleum, from Gibson's Point between above dates.

Ships.	Barks.	Brigs.	Schooners.	Total.	Total barrels.
14	83	8	5	110	65,000

Original estimated cost of improvement		$257,700 00
Increased estimate of 1874 ($40 per cubic yard for rock instead of $25)		42,000 00
Increase for additional depth and width at the mouth		75,000 00
Total		374,700 00
Total amount appropriated		195,000 00
Total amount expended		164,676 22

This work is in the collection district and port of Philadelphia. The nearest light-house is Fort Mifflin Light, and the nearest fort is Fort Mifflin.

The amount of revenue collected at Philadelphia during the year ending June 30, 1878, was $6,969,203.17.

Money statement.

July 1, 1877, amount available	$14,003 79	
Amount appropriated by act approved June 18, 1878	30,000 00	
		$44,003 79
July 1, 1878, amount expended during fiscal year		13,680 01
July 1, 1878, amount available		30,323 78
Amount (estimated) required for completion of existing project		179,700 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		50,000 00

Very respectfully, your obedient servant,

THOS. VALENTINE,
Assistant Engineer.

Col. J. N. MACOMB,
Corps of Engineers, U. S. A.

E 7.

IMPROVEMENT OF DELAWARE RIVER BELOW PETTY'S ISLAND.

REPORT OF MR. THOMAS VALENTINE, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Philadelphia, Pa., July 9, 1878.

COLONEL: I have the honor to submit herewith my report of operations for the year ending June 30, 1878, for improving Delaware River below Petty's Island.

During the past year the work of improvement upon this river, under contract with the American Dredging Company of Philadelphia, Pa., dated November 17, 1876, was continued in increasing the width of the new channel at Fort Mifflin Bar, at the southerly end or entrance into the New Jersey channel; the partial removal of a deposit of sand and mud from along the axis of the channel near the entrance to the Pennsylvania channel on the north, with a view in each case to afford 22 feet depth of water, mean

low-water of spring tides; also the removal of the wreck of sloop Spray from the channel just above Pea Patch Island, Fort Delaware. Operations at Fort Mifflin Bar were in progress until September 29, 1877, when work was suspended for the season. About 62,000 cubic yards of material were removed.

The continuation of the improvement of this river will be executed under the appropriation of $100,000 made by act of Congress approved June 18, 1878, for "improving Delaware River below Bridesburg." Examinations are now in progress to determine the character and extent of the work to be done during the present season.

Original estimated cost of improvement	$275,000 00
Total amount appropriated	40,000 00
Total amount expended	33,859 15

Money statement.

July 1, 1877, amount available	$25,836 05	
Amount appropriated by act approved June 18, 1878, "improving Delaware River below Bridesburg, Pa."	100,000 00	
		$125,836 05
July 1, 1878, amount expended during fiscal year		19,695 20
July 1, 1878, amount available		106,140 85
* Amount (estimated) required for completion of existing project		
Amount that can be profitably expended in fiscal year ending June 30, 1880		90,000 00

Very respectfully, your obedient servant,

THOS. VALENTINE,
Assistant Engineer.

Col. J. N. MACOMB,
Corps of Engineers, U. S. A.

E 8.

IMPROVEMENT OF DELAWARE RIVER BETWEEN TRENTON AND WHITE HILL, NEW JERSEY.

REPORT OF MR. THOMAS VALENTINE, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Philadelphia, Pa., July 9, 1878.

COLONEL: I have the honor to submit herewith my report of operations for the year ending June 30, 1878, for improving Delaware River between Trenton and White Hill, N. J.

No work has been done for the improvement of this river between Trenton and White Hill since operations suspended in the fall season of 1875. At that time a channel had been excavated along the northerly and easterly side of Periwig Island, with a width of not less than 125 feet, affording 6 feet depth of water at low tide.

By act approved June 18, 1878, $10,000 were appropriated for this work.

Previous to submitting a project for the application of this sum it is proposed to make an examination of the channel at such points between Trenton and White Hill, with a view of determining the extent and character of the obstructions and the best method for their removal.

Trenton is in the collection-district of Burlington, Philadelphia being the nearest port of entry. The nearest light-house and fort are, respectively, Fort Mifflin Light and Fort Mifflin.

The revenue collected at Philadelphia during the year ending June 30, 1878, amounted to $6,969,203.17.

Original estimated cost of the work	$75,000 00
Total amount appropriated to June 30, 1878	55,000 00
Total amount expended to June 30, 1878	45,000 00

* This work will be continued under the new head of appropriation as above, and a new estimate must be presented with revised project as soon as the examinations now in progress shall afford the requisite information.

Money statement.

mount appropriated by act approved June 18, 1878	$10,000 00
ıly 1, 1878, amount available	10,000 00
mount (estimated) required for completion of existing project	20,000 00
mount that can be profitably expended in fiscal year ending June 30, 1880.	20,000 00

Very respectfully, your obedient servant,

THOS. VALENTINE,
Assistant Engineer.

Col. J. N. MACOMB,
Corps of Engineers, U. S. A.

E 9.

IMPROVEMENT OF BROADKILN RIVER, DELAWARE.

No work has been done at the improvement of this river since the spring of 1874, when the appropriation of $10,000 was exhausted.

Should an appropriation be made by Congress, it is proposed next season to continue the original project for the improvement by dredging the river at the shoal places, and by opening an inlet into the bay at the junction of the Broadkiln and Lewes creeks.

This work is in the collection-district of Wilmington, Del., which city is the nearest port of entry. Fort Delaware is the nearest fort, and Delaware Breakwater Light is the nearest light-house.

Original estimated cost of work	$80,447 00
Total amount appropriated to June 30, 1878	10,000 00
Total amount expended to June 30, 1878	10,000 00

Money statement.

Amount (estimated) required for completion of existing project	$70,447 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.	10,000 00

E 10.

IMPROVEMENT OF THE NORTH AND SOUTH BRANCHES OF SHREWSBURY RIVER, NEW JERSEY.

No work has been executed for the improvement of this river since 1873.

During the season of 1875 a partial survey of the north branch and main river was made under the direction of Lieut. Col. J. D. Kurtz, Corps of Engineers.

During the present season it is proposed, as recommended in my letter of February 27, 1878, to the Chief of Engineers, to make a thorough survey of the river before submitting a project for applying the sum of $18,000, appropriated June 18, 1878.

Money statement.

Amount appropriated by act approved June 18, 1878	$18,000 00
July 1, 1878, amount available	18,000 00

E 11.

IMPROVEMENT OF COHANSEY CREEK, NEW JERSEY.

REPORT OF MR. JOHN J. LEE, ASSISTANT ENGINEER.

ENGINEER OFFICE,
Fort Delaware, July 1, 1878.

COLONEL: I have the honor to submit the following report of operations in improving Cohansey Creek, New Jersey, for the year ending June 30, 1878.

This improvement remains in an incomplete condition, no appropriation having been made for it for the last four fiscal years.

It is proposed to expend the amount appropriated for the ensuing year in deepening and widening the channel according to the original project.

For continuing this improvement an appropriation of $10,000 is asked for the next year.

Cohansey Creek is in the collection-district of Bridgeton, N. J., which is the nearest port of entry. Fort Delaware is the nearest fort, and Cohansey Light the nearest light-house.

Original estimate of cost	$30,000 00
Total amount appropriated	15,000 00
Total amount expended	10,000 00

Money statement.

Amount appropriated by act approved June 18, 1878	$5,000 00
July 1, 1878, amount available	5,000 00
Amount (estimated) required for completion of existing project	15,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880	15,000 00

Very respectfully, your obedient servant,

JNO. J. LEE,
Assistant Engineer.

Col. J. N. MACOMB,
Corps of Engineers, U. S. A.

E 12.

IMPROVEMENT OF CHANNEL OF SALEM RIVER, NEW JERSEY.

No work has been done for the improvement of this river since operations were suspended in 1871.

By act approved June 18, 1878, $3,000 were appropriated for this work.

Previous to submitting a project for the application of this sum it is proposed to make an examination of the obstructions at the mouth of the river, with a view of determining the extent and character of the obstructions, and the best method of their removal.

Money statement.

Amount appropriated by act approved June 18, 1878	$3,000 00
July 1, 1878, amount available	3,000 00

E 13.

DELAWARE BREAKWATER.

ɪ remains substantially in the same condition as at the date annual report.

l hereto is a table showing the number of vessels seeking e Breakwater Harbor annually for 14 years, and their total s, between 1833 and 1878.

ssels taking refuge in Delaware Breakwater Harbor during the years stated below.

ars.	Ships.	Barks.	Brigs.	Schooners.	Sloops.	Pilot-boats.	Steamers.	Total.
.....	22	.....	178	372	167	127	.....	866
.....	165	.....	732	3,191	765	685	.....	5,538
.....	107	.....	1,060	5,335	802	794	.....	8,098
.....	342	.....	1,937	7,742	358	874	.....	11,253
.....	35	247	1,085	5,098	90	.....	114	6,669
.....	55	239	879	8,087	253	.....	246	9,759
.....	113	290	825	8,000	307	.....	279	9,814
.....	119	639	1,008	8,588	522	923	629	12,428
.....	192	877	867	13,976	734	(*)	844	17,490
.....	166	605	623	9,797	477	.....	781	12,449
.....	222	804	581	9,527	420	.....	843	12,397
.....	370	2,762	587	10,382	447	.....	945	15,493
.....	558	4,146	626	10,027	370	.....	1,092	16,819
1878, to July 1, ...	228	1,331	309	4,467	272	.....	708	7,315
rs	6,844	16,471	33,171	242,591	17,471	13,688	10,886	341,122

* Pilot-boats classed with schooners. † Six months' return.

E 14.

RT-WARDEN'S LINE, PHILADELPHIA, PENNSYLVANIA.

stion remains as last reported, nothing on the subject having from the municipal authorities of Philadelphia.

' is now being made by a party from the United States Coast the entire river front, and as soon as the result of this survey , a report and recommendation will be made relative to the n's line.

APPENDIX F.

ANNUAL REPORTS UPON THE WORKS IN CHARGE OF MAJOR WILLIAM P. CRAIGHILL, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1878, BY CAPTAINS JAMES W. CUYLER AND CHARLES B. PHILLIPS, CORPS OF ENGINEERS, TEMPORARILY IN CHARGE.

UNITED STATES ENGINEER OFFICE,
Baltimore, Md., July 13, 1878.

GENERAL: I have the honor to forward herewith the annual reports for the year ending June 30, 1878, for works of improvement of rivers and harbors which have been in my charge during a portion of that period. All these works were in charge of Maj. W. P. Craighill, Corps of Engineers, until the 26th of March, 1878. On that date I temporarily relieved Major Craighill of the charge of the works, and remained in charge until the close of the fiscal year. Efforts have been made to procure full statistics as to the commercial importance of each improvement, but the efforts have not been successful in some cases, as was desirable.

I am, general, very respectfully, your obedient servant,

CHAS. B. PHILLIPS,
Captain of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

F 1.

IMPROVEMENT OF CHESTER RIVER AT KENT ISLAND NARROWS, MARYLAND.

The object of this improvement has been fully set forth in previous annual reports. Briefly, it consists in dredging a channel 100 feet in width and 7 feet in depth from Easton Bay to Chester River, a distance of 12,900 feet, including a passage through the causeway connecting Kent Island with the mainland.

This project had at the date of the last annual report been carried out, except that the channel on the Easton Bay side of the causeway as well as about two-fifths of the length of the channel on the Chester River side had been completed to only 80 feet in width.

The passage through the causeway had also been cut to the full width allowed by the draw (60 feet) and had cut out by the action of the current to a depth at this point of 21 feet.

To give additional vent for the water, the causeway had also been cut away under the counterpoise of the draw, by the government, and at the draw abutment one span of pile-bridge had been put in by the county authorities with the same object in view.

An examination of the entire channel, made shortly before the date of the last annual report, showed that the channel was maintaining itself well at all points, except at the bend immediately below (Easton Bay side) the causeway. Here it was found that the volume of water pass-

ing through the cut in the causeway had taken up a different direction, both on flood and ebb from that which it had while the causeway remained intact. The current had left the dredged channel around the flats, and was found to be making its way directly across the point, and had already cut out new and deep pockets, both above and below, in the new direction of the current.

The distance across this point between the 7-feet contours was about 600 feet.

As the old channel around the point was gradually filling up and becoming useless, it was determined to assist nature in her evident purpose of cutting a new and more direct channel from the draw across this point.

There remained on hand on July 1, 1877, $4,000, the balance of the appropriation, $5,000, of August 14, 1876, which balance became available on the 31st of the previous March.

It was determined to devote so much of this balance as might be necessary to dredging across this point, and to use the remaining funds in giving additional width to the Chester River side of the channel, especially at the abrupt turn from the Narrows into Chester River.

Accordingly the sanction of the Chief of Engineers having been obtained, a dredge and two scows were chartered by the day to execute the above contemplated work. Later it was found necessary to also charter a small tug, so much time was lost by running the scows by hand. Dredging in accordance with the above project was commenced on the 6th of July last at the bend on the Easton Bay side of the causeway, and was continued until the 8th of the following September, on which date the channel across the point was completed.

The channel was 600 feet in length, 75 feet in breadth, and 7 feet deep at ordinary low-water. Thirty-seven full days of 10 hours each were made by the dredge during the period mentioned, and 8,330 cubic yards of material were removed.

Dredging at the bend having been completed the dredge was removed to the Chester River side of the causeway, and was engaged in widening portions of this channel from the 8th to the 26th of September last. One old unfinished cut, 120 yards in length, was completed, and two sharp points, at the abrupt turn from the Narrows into Chester River, were trimmed off.

Nine days in all were made by the dredge on the Chester River side, and 2,640 cubic yards of material were removed.

On the 26th of September, operations were suspended, the appropriation having become exhausted.

In December last, an examination was made of the new cut across the point near the causeway. It was found that the channel had stood well, no less than 7 feet at ordinary low-water being found. During the month of June, 1878, another examination was made of this cut and the vicinity of the draw-bridge. It was found at this late examination that some shoaling had taken place in the new cut across the flats and that not over 6 feet could be carried at low-water. The soundings, as shoal as 6 feet, occupied, however, not over one-sixth the entire length of the cut, the depth for the remaining distance having maintained itself well.

This shoaling appears to be due to the large amount of scour at the draw.

It was found that at the draw the water had deepened to 24 feet, and under the counterpoise, of the draw a depth of over 12 feet was found. When this scouring ceases, as it must do when a sufficient area of cross-

section has been attained, it is probable that the cut below will remain open permanently.

The passage through Kent Island Narrows is now used to a considerable extent by sailing-vessels, and is of great benefit to traders between Easton Bay and Baltimore, and other points on the northern portions of the Chesapeake.

It is to be regretted, however, that the channel is rarely ever used by steamers. Sufficient width and depth already exist for the class of steamers that was expected to pass through, and it is believed that when the route becomes better known its use by steamers will be adopted.

The original estimate for this work was $23,000.

Twenty-eight thousand dollars were appropriated in all up to June 30, 1878, of which amount $3,000 remains unexpended, having just been made available. This balance will be sufficient to nearly carry out the original project, which will have cost more than the original estimate by reason of long and unavoidable delays.

This work is in the collection district of Baltimore.

Money statement.

July 1, 1877, amount available	$4,033 23	
Amount appropriated by act approved June 18, 1878	3,000 00	
		$7,033 23
July 1, 1878, amount expended during fiscal year		4,028 40
July 1, 1878, amount available		3,004 83

F 2.

IMPROVEMENT OF THE HARBOR AT BALTIMORE, MARYLAND.

The object of this work has been fully set forth in previous annual reports. Briefly, it has been to secure by dredging a channel sufficiently deep and wide to accommodate vessels drawing 22½ or 23 feet coming to or going from the city of Baltimore, at any ordinary stage of the tide. As regards depth, this object was accomplished in 1874, but the desired width has not yet been obtained. Since 1874, the appropriations for the work have been but slightly in excess of the amount which it was anticipated would be required annually to maintain the channel; but the idea of securing additional width has been constantly kept in view, and each year after the usual annual reparations have been made, all remaining funds have been devoted to this purpose. The increased widths that have thus from time to time been obtained, have afforded considerable relief to shipping, but more is needed to accommodate the large deep-draught steamers which ply to and from the port, and which are constantly increasing both in number and size. The draught of these steamers is so great that the suction due to the proximity of their keels to the bottom makes them difficult to steer, and they are constantly liable to run against the sides of the channel, causing damage to themselves as well as to the channel itself.

During the past fiscal year dredging has been confined to the lower end of the Brewerton Channel and to the angle formed by the intersection of the Brewerton and Craighill Channels. The object of dredging at the former locality was to restore the original depth of channel

from its lower end up to a point opposite to and a little above North Point. This portion of the channel has frequently been referred to in previous reports as being constantly liable to deterioration as it necessarily projects into the current of the upper bay, caused by the Susquehanna River.

At the latter locality the object was to facilitate the passage of vessels from one to the other channel, by cutting off a large triangular piece at their intersection.

In April, 1877, the balance ($35,000) of the appropriation of August 14, 1876, was rendered available for expenditure.

A project for the expenditure of this amount having been submitted to the Chief of Engineers, and by him approved, proposals were invited for dredging, and were opened June 1, 1877. A contract was entered into with Mr. A. P. Brown, of Washington, D. C. (the lowest bidder), for the removal of 300,000 cubic yards of material, at the rate of 9¼ cents per cubic yard; the work is to be commenced July 1, 1877, and to be completed June 30, 1878.

The contractor's machinery, consisting of one dipper dredge, attendant scows, and one tug, arrived at Baltimore, was placed in position, and commenced work at the lower end of the Brewerton Channel, on the 16th of July, 1877, and continued work through the remainder of July and the entire month of August.

During this period it became manifest that the dredge was incapable of executing the work required of it, having dredged only 23,000 yards, while the proportional amount to be dredged monthly was 25,000 yards.

The attention of the contractor was called to the above fact, and on the 10th of the following month (September) he put a large "clam-shell" dredge upon the work, keeping the dipper dredge at work meanwhile until the 15th of September, when the latter was finally taken off the work, being entirely unadapted to the locality and the work required of it. The large "clam-shell" dredge was also withdrawn from the work on the 25th of September, owing to some (supposed) misunderstanding between the contractor and the owner of the dredge. At the close of September, however, another large "clam-shell" dredge was on its way from Philadelphia to the work. This dredge encountered a severe gale on the 4th of October, while at anchor near the Delaware breakwater, and was driven ashore. This accident and the time required for repairs at Baltimore caused a suspension of operations until the 20th of October, on which date the dredge resumed work and carried the contract through to its completion.

Work was suspended from the 25th of December until the 6th of February last on account of rough weather and the expectation that the harbor would become closed by ice. On the latter date, as the harbor still remained open, dredging was resumed. On the 9th of February, the last (7th) interior cut in the Brewerton Channel was completed, thus restoring a depth of 25 feet at mean low-water over its entire width from its lower end up to a point opposite to North Point; 132,000 cubic yards of material were removed to accomplish this.

On the completion of this work dredging was commenced at the angle formed by the intersection of the Brewerton and Craighill Channels, and was continued until the 3d of May last. The area dredged over here consisted of a large triangular piece shown on the accompanying sketch at the intersection of the channels, all of which was dredged to 25 feet in depth at mean low-water, thus affording much relief to vessels passing from one to the other channel; 112,000 cubic yards of material were removed from this locality.

On the completion of this work an entirely new cut was commenced on the west side of the Brewerton Channel, commencing at the lower end, and was carried as far as available funds would permit, or until the completion of the contract. Work was closed on the 14th of June, the new cut having been carried about one-third of the way from the lower end of the channel at North Point, 56,000 cubic yards of material having been removed from this cut. Total amount of material removed during the year under the contract, 300,145 cubic yards. An examination of all the area dredged during the year was made in June last, after the close of operations, and the results plotted. Quite extensive repairs to the tug Leslie were made during the past fiscal year. A new boiler was put in place of the old one, the latter having been in use 16 years. Her machinery was also thoroughly overhauled, a new pilot-house constructed, and a new propeller put on her. These repairs were done during the winter months. Since March last she has remained constantly in commission.

An appropriation of $75,000 was made in June last, for the fiscal year ending June 30, 1879; $185,000 were asked for that year to complete the existing project, leaving $110,000 yet needed to complete it.

To this sum add $50,000 for estimated amount required for reparations, and we have, as the amount that can be profitably expended in the fiscal year ending June 30, 1880, $160,000.

Money statement.

July 1, 1877, amount available	$55,528 96	
Amount appropriated by act approved June 18, 1878	75,000 00	
		$130,528 96
July 1, 1878, amount expended during fiscal year		54,118 46
July 1, 1878, amount available		76,410 50
Amount (estimated) required for completion of existing project		160,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880		160,000 00

COMMERCIAL STATISTICS.

CUSTOM-HOUSE, BALTIMORE, MD.,
COLLECTOR'S OFFICE, *July* 19, 1878.

COLONEL: In compliance with your request of June 14, 1878, asking for certain statistics relative to the commerce of this port, I have the honor to present the following statement in accordance therewith for the fiscal year ending June 30, 1878:

Duties collected in coin	$2,848,380 13
Receipts in currency—tonnage, inspection fees, &c	186,778 15
Value of dutiable merchandise imported	6,372,512 00
Value of free merchandise imported	10,566,116 00
Total	16,938,628 00
Duties collectible thereon in coin	3,029,073 00
Merchandise entered in bond for transportation to interior ports:	
Value of merchandise	299,916 00
Duties thereon	114,519 57
Merchandise of domestic growth and manufacture exported	45,633,521 00

The commodities exported of chief value were bread and breadstuffs, provisions, petroleum, tobacco (leaf and manufactured), live-stock, canned fruits, &c., and a numerous variety of manufactured articles of domestic production.

The increase in the matter of exports for the fiscal year referred to over that of the previous one amounts to about $6,000,000. The growth of the trade of Baltimore with foreign markets in this branch of commerce within the last few years has been most

marked and rapid in its expansion, and from the evident impetus it has received, the limits it may reach in the near future may be conjectured, but not accurately predicted.

For the fiscal year ending 1871 the value of domestic exports (foreign) amounted to $15,037,855. Within the period of seven years they have attained to nearly $46,000,000.

It is from this branch of commerce of this port that the basis is to be accepted upon which to judge of its future expansion as a commercial city, and its demands and needs as such to meet the requirements that the future will exact.

The decline in the matter of importation is not at this time an entertainable basis to judge of the capabilities of a seaport for trade, nor to draw therefrom any inferences as to its future. It is well known that, as a result of the pressure of the times, our people generally are beginning to rely almost wholly upon their own resources, and, under a spasm of economy, are spending as little money as possible for foreign productions. To this has been largely due the falling off in the importations to this port; but notwithstanding this policy of our people, the importations here would have reached a fair average had it not been for the unfortunate question arising out of the "*colored sugar dispute.*" Because of that question, still unsettled, the importations of sugar to this port were seriously affected; and it being one of the chief and heaviest commodities imported, the result has caused a visible decline in the importations. And although the disputed question of "colored sugar" relates to all other seaports where sugar is imported, the importations here have been affected to a greater extent than elsewhere.

The next branch of this statement relates to the bulk of tonnage traversing the harbor of Baltimore, foreign and coastwise, and affords a reliable basis as to the condition and growth of the commerce of the port:

Vessels arriving (foreign) of all nationalities	1,408
Tonnage of the same	951,521
Number of clearances of same	1,475
Tonnage of same	1,005,189
Arrivals coastwise	1,437
Tonnage	1,061,712
Clearances coastwise	1,794
Tonnage	1,266,854

The above does not include the large number arriving coastwise that do not enter or clear.

	Tons.
Total amount of tonnage entering and departing the harbor of this port for the fiscal year 1878	4,285,276
Previous year	3,011,469
Increase	1,273,807
Increase of year 1877 over 1876	1,322,586
	2,596,393

The above shows an increase for the last two fiscal years of 2,500,000 tons, and affords the best criterion of the state of commerce at this port, and at the same time shows unmistakably an improved and increasing growth.

This increase in the trading tonnage of this port is due to some extent to the increasing number of first-class steamships entering and departing its harbor, to which reference will hereafter be made.

The registered outstanding tonnage of this district is as follows:

	Vessels.	Tons.
Registered, permanent, sail	74	23,519
Registered, temporary, sail	39	16,817
Enrolments, permanent, sail	541	23,797
steam	113	37,367
barges	2	134
Enrolments, temporary, sail	28	6,644
Licenses under 20 tons, sail	204	2,543
steam	18	225
Total	1,019	111,046
Last year	995	107,061
Increase	24	3,985

This ratio of increase is in accord with the other salient fact, above referred to, showing a healthy growth of the commerce of this port. The same foreign and coastwise lines of steamships, referred to in detail in my statement to you of last year, are still maintained between this and foreign ports, but with some increase in ships on certain lines.

From December of last year until May, 1878, the Allan line of steamships doubled the number of ships plying between this port and Liverpool by placing on the line some of their finest vessels. It is expected that upon a return of the winter season the same schedule of sailing time will be resumed. The coastwise steamers plying between the Southern, Northern, and New England ports maintain a vigorous existence, and much of the commodities they bring are transferred at the piers of the Baltimore and Ohio Railroad Company, for the West by rail and for Europe by the steamship lines. Outside of these regular lines there are a number of other steamships, continually increasing in number, arriving almost daily from foreign ports to take in cargoes for Europe.

At Locust Point, on the property of the Baltimore and Ohio Railroad Company, a new system of inspecting tobacco has been introduced which has met with extraordinary success. The tobacco so inspected comes from the West and South, and is shipped to Europe by the steamships mentioned. The tobacco trade has received a great and healthy stimulus by this improved system of inspection, and from indications so flatteringly afforded promises to be very extensive, and will contribute, with other growing interests, to increase the requirements of good harbor facilities.

In my previous report it was incidentally mentioned that new projects of enterprise were then on foot that would tend to the expansion of the commerce of this port. One of the projects was a "pipe-line" from the oil regions to tidewater at this port.

That enterprise it seems was thereafter actively entered upon, and would have doubtless by this time been an accomplished fact had its progress not been embarrassed by supposed rival interests. Another enterprise was the exportation of fresh meats. This latter project has not yet been attempted, but cattle and live-stock in large quantities have been shipped recently from this port to Europe, and the trade in that line promises to increase. Reference was also made to the actively agitated question of a ship-canal to unite the Chesapeake and Delaware bays. Since then influential bodies of citizens, representing various sections of the country, have met and recommended the construction of said water outlet upon grounds substantially the same as those suggested in my previous statement.

That this valuable enterprise to the nation, as well as to this port, will be entered upon and completed is evidently a work only of time, and that not far distant.

Deeming these incidental questions relating to the commercial prosperity of this port, together with the questions of fact that its commerce itself affords, as meeting your inquiries, they are very respectfully communicated, with the hope that they may aid you in any effort you may make in behalf of the commercial interests of this port.

I remain, very respectfully,

JOHN L. THOMAS, JR.,
Collector.

Col. W. P. CRAIGHILL,
Corps of Engineers, U. S. A.

F 3.

IMPROVEMENT OF WICOMICO RIVER, NEAR SALISBURY, MARYLAND.

As stated in the last annual report, the original plan of improvement for this locality, which was to secure, by dredging, a channel 75 feet in width and 7 feet in depth at ordinary low-water, was, owing to insufficient means, so modified as to contemplate the dredging of a channel only 50 feet in width and 5 feet in depth at ordinary low-water.

In January, 1876, the appropriation of March 3, 1875, became exhausted. At this time the channel, as per modified plan, was completed, except for a distance of 300 feet, which was made only 28 feet in width. An appropriation of $5,000 was made for this work by act of Congress approved August 14, 1876. This appropriation did not become available, however, until March 31, 1877. At the date of the last annual report arrangements had been made, with the approval of the Chief of Engineers, for recommencing work; the work to consist simply in dredg-

ing to secure additional width of channel throughout its entire length, and to restore a depth of 5 feet in the turning-basin near the town, which had filled up considerably since the close of operations in January, 1876.

Owing to some delay on the part of the contractor in getting his machinery ready, he having introduced some improvements in his mode of depositing material by means of chutes, dredging was not commenced until August 30, 1877. From this date dredging continued without interruption until the 26th of November last, when the channel had been widened to 70 feet throughout its entire length with a depth of 5 feet at ordinary low-water from the town of Salisbury to the deep water below, a distance of about 7,000 feet; 12,197 cubic yards of material were removed to accomplish this, all of which material was deposited by means of chutes, either behind the dikes already constructed or on the adjacent flats, at a minimum distance of 120 feet from the channel.

On the 26th of November the dredge was moved up the river and put in position at the turning-basin near the town. By an arrangement previously made with the adjacent wharf-owners the latter agreed to receive the removed material upon their wharves, thus permitting the continued use of the chutes, and saving the expense of towing. Dredging was continued at the turning-basin until the 5th of January last, when the basin had been excavated to a depth of 5 feet at ordinary low-water, and over as great an area as the safety of the wharves on either side would permit; 3,950 cubic yards of material were thus removed from the basin, making, with the amount removed from the channel below, a total of 16,147 cubic yards.

On the 5th of January all dredging was suspended on account of the near exhaustion of available funds. Late in January last a careful examination of the entire channel and turning-basin was made and the results plotted. The examination proved that the dredging had been well executed, only two or three small lumps being found with less than 5 feet of water at ordinary low-water. It was estimated that these lumps would aggregate 50 cubic yards in bulk, which amount was deducted from the aggregate amount of dredging at the final settlement with the contractor.

The longitudinal dikes below the town, which were built for the most part by the United States, have suffered some damage during the past year, partly from the action of muskrats and partly from the practice of vessels attaching lines to the piles. The approval of the Chief of Engineers having been obtained, these dikes were repaired during the month of June last as thoroughly as the limited state of available funds would permit.

Thirty-two linear feet of dike have been entirely renewed, requiring the use of 200 feet, board-measure, of timber and sheet piling, and the driving of 4 round piles, as well as the excavation and replacing of a considerable quantity of earth behind the dikes.

Mention was made in the last annual report of the fact that the owners of saw-mills on the stream above the town of Salisbury were in the habit of allowing sawdust to flow into the stream, much to the detriment of the river below, particularly at the turning-basin near the town.

It is now but just to state that this practice has been altogether abandoned by all the mill-owners, and thus one great cause of the rapid filling of the basin has been removed.

The appropriations for this work have been June 10, 1872; March 3, 1873; June 23, 1874; March 3, 1875; August 14, 1876; and June 18, 1878. Total, $30,000.

Should the original plan be carried out, an appropriation of $10,000 will still be required.

This improvement is in the collection-district of Baltimore.

Money statement.

July 1, 1877, amount available	$4,700 70	
Amount appropriated by act approved June 18, 1878	5,000 00	
		$9,700 70
July 1, 1878, amount expended during fiscal year		4,665 70
July 1, 1878, amount available		5,035 00
Amount (estimated) required for completion of existing project		10,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880		10,000 00

COMMERCIAL STATISTICS.

SALISBURY, MD., *June* 7, 1878.

DEAR SIR: I have the honor to report as a near approximation of the commerce of Salisbury for the past year the following, viz:

Fifteen schooners, registering 913 tons, and 51 sloops and smaller craft trade from the town. Among our shipments are 10,000,000 feet rough lumber; 3,000,000 feet dressed flooring; 900,000 peach crates; 400,000 packing cases; 5,000 berry crates; 10,000 finished hubs; 4,000 cords cordwood; 3,000 cords kindling wood; 4,000 railroad ties; 61,000 bushels grain; 13,000 bushels corn meal; 1,800 barrels flour; 13,000 pounds wool; 225,000 quarts strawberries; 15,000 melons; 58,000 quarts wild berries; 4,000 barrels vegetables; 6,000 crates peaches; 31,000 bushels oysters; 60,000 bushels oyster-shells; 220 tons fertilizers; 2,000 tons coal. Sales of general merchandise from 30 stores of various sizes foots up $723,000. Continuous low prices of lumber diminishes the production of this our greatest industry.

Twenty new buildings, a wharf, 2 iron founderies, a power-printing press, show indications of prosperity, notwithstanding dullness of business. One steamboat and all our bay craft use with satisfaction and economy the channel constructed by the government, which is a valuable improvement. A moderate additional sum would double its value, and it is hoped Congress may appropriate the same.

Very truly, yours,

GEO. W. PARSONS.

Capt. C. B. PHILLIPS.

F 4.

IMPROVEMENT OF JAMES RIVER, VIRGINIA.

The operations of the year have not been extensive, the available funds having been very limited. They have been conducted in furtherance of the existing project for the improvement of this river, and have consisted principally in the removal by blasting of rock, dredging, and the construction of wing-dams.

On the 1st of July, 1877, the amount available for this work was but $17,000, being the balance of the appropriation of August 14, 1876.

During the month of July, 1877, the machinery for blasting and removing rock was employed at Rocketts Reef and vicinity.

One pile-driver and one dredge, with accompanying tug and scows, were employed during July, August, and September, and three dredges, with accompanying tugs and scows, were employed during the month of October. Since the close of the latter month no work, exclusive of surveys, has been done by the United States during the fiscal year.

During this period of active operations, 166 cubic yards of rock were

removed from Rocketts Reef and vicinity, 10,920 cubic yards of material were dredged from Richmond Bar and Randolph's Flats, and 3,350 linear feet of wing-dams were constructed between Richmond Bar and Warwick Bar.

The city of Richmond has continued to co-operate with the United States in improving the channel.

The operations of the city have been mostly confined to dredging at Drury's Island Cut, Richmond Bar, Randolph's Flats, and Warwick Bar; 53,000 cubic yards of material have been removed from these localities by the city during the year.

That portion of the machinery used for blasting and removing rock belongs to the United States. The remaining portion of the machinery, used for dredging, pile-driving, &c., belongs to the city of Richmond, and was hired by the United States, the latter paying as rental the actual cost of repairs while in its service.

Mr. H. D. Whitcomb has continued to be local engineer for the United States, at Richmond, while holding at the same time the position of engineer for the city, in its joint operations for this improvement. His report, giving in detail the operations of the year, is appended hereto.

While the operations of the year have been but limited, the results have, on the whole, been satisfactory. With the exception of two short distances, one at the lower end of Drury's Island, the other at Richmond Bar, 16 feet at ordinary high tide, from Rocketts Reef to the sea, has been obtained. At the excepted points hardly 15 feet are to be found. It is believed that, by a judicious contraction of the river at these points, the desired 16 feet may be obtained and maintained without further dredging.

On Rocketts Reef as much water is now to be found (14.2 feet) as can be carried with safety to the wharves above.

The number and size of vessels trading to this port are constantly increasing. A greater width and depth of channel is requisite for the wants of commerce. The delays due to meager appropriations, and the resulting loss to and decay of the plant and the works already completed, are such that it cannot be expected that the original project, of obtaining a channel 180 feet in width and 18 feet in depth, can be carried out even when the aggregate appropriations shall have amounted to the original estimated cost.

Should the whole amount asked for be granted in two successive appropriations, there is no reason to doubt but that this important improvement could be carried out as designed without exceeding the limit of the estimate.

There was left of estimate to be provided for at date of last annual report, $258,024; $70,000 were appropriated by act approved June 18, 1878, leaving yet to be provided for $188,024.

Money statement.

July 1, 1877, amount available	$16,902 92	
Amount appropriated by act approved June 18, 1878	70,000 00	
		$86,902 92
July 1, 1878, amount expended during fiscal year		16,890 98
July 1, 1878, amount available		70,011 94
Amount (estimated) required for completion of existing project		188,024 00
Amount that can be profitably expended in fiscal year ending June 30, 1880		150,000 00

REPORT OF MR. HENRY D. WHITCOMB, ASSISTANT ENGINEER.

RICHMOND, VA., *June* 1, 1878.

CAPTAIN: I have the honor to submit the following report on the improvement of James River, from June 1, 1877, to May 31, 1878, inclusive.

After paying the accounts for May, 1877, there remained about $20,000 of the appropriation of August, 1876, unexpended.

The machinery for removing rock was employed until August, when, by order of Colonel Craighill, it was taken to the Appomattox improvement, and remained there until the appropriation for this work was too nearly exhausted to warrant its further use here. A dredge and pile-driver with steam-tug and barges were employed until September 30, and 3 dredges, with tugs and barges, in October; since then no work exclusive of surveys has been done by the United States.

The city of Richmond employed 2 dredges, 1 tug, and 1 dumping-machine from June 1 to September 30, and 3 dredges from November 1 to January 10, 1878. Since then no work has been done by the city except in repairs of machinery and in surveys. The repairs are still in progress.

The Richmond and Danville and the Chesapeake and Ohio Railroad companies and the Old Dominion Steamship Company have each done some dredging with the city machinery at their wharves, the greater part being outside the limits of the channel proper.

The channel at Goode's Rocks was completed to a minimum depth of 13 feet at low tide by 100 feet in width 13th June, and the machinery for removing rock then employed at Rocketts Reef, and in removing bowlders and small ledges in that vicinity, until August 1. A dredge was also employed in this work. The pile-driver was used in constructing timber groins on the shoals from Richmond Bar to Warwick Bar.

Cubic yards of material removed by dredging and blasting.

At what place.	By the United States.		By the city of Richmond.		Character of material.
	Earth.	Rock.	Earth.	Rock.	
Rocketts Reef	.....	542	.....	98	Granite and decomposed rock.
Drury's Island Cut	3,467	28	14,721	.....	Sand, decomposed rock, and bowlders.
Goode's Rocks	.....	35	.....	.....	Granite and cobble-stones.
Richmond Bar	4,686	.....	9,407	.....	Coarse sand.
Randolph's Flats	1,861	.....	18,131	.....	Finer sand.
Warwick Bar	906	.....	5,779	.....	Light muddy sand.
Kingsland's Reach	.....	.....	4,854	.....	Light muddy sand, some soft rock.
Total	10,920	605	52,892	98	

	Earth.	Rock.	Character of material.
By Old Dominion Southside Company	5,024	.....	Sand.
By Chesapeake and Ohio Railroad Company	11,040	25	Sand, decomposed rock, and bowlders.
By Richmond and Danville Railroad Company	3,150	30	Do.

Total by all parties: Earth, 83,026 cubic yards; rock, 758 cubic yards.

The rock removed by the city had nearly all been loosened by the United States. About 19,000 cubic yards of the earth removed by the city were deposits from the freshets of October and November.

Timber groins or wing-dams built by the United States, 3,350 feet.

For want of sufficient revetment, which was in progress, about 1,250 feet of these groins were carried away or injured during the freshets. No part of the properly protected work was materially injured.

Freshets during the year.

There were several freshets during the year, and that of November 25 was the greatest of which we have any reliable record. The river has been very full since that time and in nearly every month there have been one or more rises of from 2 to nearly

4 feet. So far as observed, the rises above mean high tide at Rocketts Reef were as follows:

	Feet.
October 5, 1877	10.33
November 9, 1877	7.50
November 25, 1877	25.12
January 15, 1878	3.35
January 31, 1878	3.30
February 11, 1878	3.80
March 14, 1878	3.80
April 11, 1878	2.00
May 7, 1878	2.76
May 16, 1878	2.80

In the flood of November 25 the river began to rise at 3.30 a. m. on the 24th, and reached its maximum about 9 p. m. on the 25th. The registering tide-gauges were removed on the night of the 24th, and shortly afterward the buildings which had held them were swept away, together with the building used as store-house and laboratory. The drilling platform was upset and injured, and is still out of repair. About 30,000 feet of pine lumber were carried off, but all recovered. It will be necessary to erect new buildings when the work is resumed, at a cost of $600 or $700.

The heights above mean high tide that this flood reached were measured at several places, and were as follows:

Place.	Extreme height noted.	Authority.
	Feet.	
Rocketts, below Gillie's Creek	25.12	Water-mark in drug-store.
Richmond Bar, lower end	22.40	Water-mark on north hill-side.
Warwick Bar, crest	20.05	Water-mark on south hill-side.
Drury's Bluff Landing	18.52	Do.
Kingsland Reach, Bennett's Wharf	16.40	Mark by Mr. Bennett.
Upper end of Dutch Gap Cut-off	14.54	Mark by Mr. Allen.
Lower end of Dutch Gap Cut-off	12.39	Do.
Varina	10.64	Mark by Mr. Aiken.
City Point	2.20	Mark by Mr. Cook.
Westover Wharf	1.82	Water-mark on beach.

The height of this flood at Rocketts was 1½ feet above the arrow on the monument erected by the city, which marks the height of the flood of 1870. Capt. R. D. Minor, engineer in charge of the improvement on the part of the city in 1870, stated that the flood of 1870 reached 24 feet ½ inch above high tide. The height of the arrow is 23 feet 6⅞ inches above present mean high tide, giving an apparent elevation in the level of high tide of 5⅝ inches since 1870. As no systematic observations on the tides had been made by Captain Minor at that date, the height of mean high tide may not have been accurately known; but it is possible that the range of the tides has increased since the deepening of the channel below. It is proper to put this discrepancy on record to prevent a future misunderstanding.

The water-marks referred to above were taken as soon as possible after the flood, but are liable to the error which may be caused by the waves of steamers. They were sometimes taken on the side where the current impinged, and sometimes on the opposite. The slopes given below are also affected by these probable errors.

Slopes of the flood of November 25, 1877.

	Feet per mile.	
On 4 miles above Richmond and Danville Railroad bridge	15.52	By Mr. R. Gordon, civil engineer.
From Richmond and Danville Railroad bridge to Rocketts	0.93	United States assistant engineers.
From Rocketts to Richmond Bar	0.91	
From Richmond Bar to Warwick Bar	1.38	
From Warwick Bar to Drury's Bluff	0.54	
From Drury's Bluff to Bennett's Wharf	0.62	
From Bennett's Wharf to Dutch Gap Cut-off	0.52	
From upper to lower end Dutch Gap Cut-off, *through the same*	19.00	
From upper to lower end Dutch Gap Cut-off, *around the bend*	0.39	
From Dutch-Gap Cut-off to Varnia Wharf	1.39	
From Varina Wharf to City Point	0.49	
From City Point to Westover Wharf	0.06	

The effects of this and preceding floods, so far as ascertained, were as follows:

The entrance to the ship-lock and the channel in front of the Old Dominion Southside Wharf were reduced in depth. From this to the lower end of Drury's Island there was no appreciable change in the channel. Opposite the lower end of the island for about 400 feet the dredged channel was shoaled so that not more than 11 feet could be carried through at low tide. A great volume of water poured over the dikes, at the head and foot of the island, and over the low ground to the eastward of this point, and these diversions of water may have been the cause of the shoal. On the crest of Richmond Bar the channel was rounded out, giving a better depth than before, and the lower part of the bar was scoured down in places to 15 feet and over at low tide.

Two of the groins or dikes at the head of Randolph's Flats (the next shoal below) were partly carried away, and the scour, although considerable, was not in the direct channel; the channel which had been dredged was partially filled, but near the injured groins there were 14 feet at low tide. These groins had not been protected with hard revetment.

From this to the end of the shoal the groins were not injured, and the channel was greatly improved. On the lower 500 feet there were from 15 to 16½ feet in the channel at low tide.

From this to the crest of Warwick Bar the groins were more or less injured and had very little effect. There is a shoaling in one place due apparently to the scour on Randolph's Flats above.

The two lower groins alone, which were on opposite sides of the river at the crest of the bar, remained nearly entire, and the effect of these and of the remains of others immediately above was very great. From 300 feet above to 700 feet below there was a wide channel with from 15 to 20 feet at low tide, where in the preceding month we had been dredging to get a channel 13 feet deep. The channel through the old crest 2,000 feet below (where obstructions were placed during the civil war) was somewhat reduced in depth from the scour above. There were several ridges with intervening depressions at right angles to the current extending to about 3,000 feet below the lowest groin. All this part of the river is wider than between the groins, and needs regulation.

From Warwick Bar to Kingsland Reach, 10½ miles below Richmond, no thorough examination has been made since the freshet, but no marked change in the channel is suspected. The shoal in Kingsland's Reach was increased in length and height, and had one sounding of only 10 feet at low tide in the channel. The river is 1,100 feet wide, 300 feet more than it is immediately above and below. Just above the stream bends suddenly to the left, and just below as suddenly to the right, turning a sharp elbow, having low banks, across which the flood poured, reaching the river below in about ⅓ the distance around. This reduced the velocity over the shoal, and accounts for its increase. A levee will probably be needed here in addition to works heretofore projected, none of which have been executed.

The shoal in Trent's Reach was also increased, having one sounding of only 6½ feet in channel where there had been 9½ feet a few months previous. As this shoal is now avoided by the Dutch Gap Cut-off, no effort has been made to restore the channel. At the other shoal mentioned the city dredged channels to a minimum depth of 15 feet at *high tide*, and at Warwick Bar and Kingsland's Reach to 16½ and 17 feet respectively, which required 25 days' work of 3 dredges.

At the height of the flood of November 25 the difference in elevation at the upper and lower end of Dutch Gap Cut-off was 2.15 feet in a distance of about 600 feet. There was some abrasion above ordinary water-level in the light gravelly material, especially at the upper left-hand side. In the indurated clay or marl through which the cut is made under water there was no apparent scour. The deep-water line at the lower end is now somewhat extended into the cut, but apparently not into the indurated clay; but a more thorough examination is needed to enable me to speak confidently.

A few soundings were taken in Varina Reach, which indicated no change injurious to navigation. Besides this no examinations have been made of the river below Dutch Gap since the freshet.

The effect of these freshets was good wherever the river had been contracted in width, but at several points it is evident that further contraction and some changes in direction are needed. As a rule, the widths heretofore adopted are found to be proper for the bends, or where the current sets to one shore continuously, but where there is a "cross-over" a further contraction is necessary to maintain the desired depth.

The following statement shows the widths, depths, and areas opposite the groins on

two of the shoals improved in 1874 and in March, 1878; also the amount of contraction and the increase in area since the contraction was made.

Number of groin.	Width of whole river at low tide, 1874.	Greatest depth at low tide, 1874.	Area of whole river in cross-section at low tide, 1874.	When contracted to present width.	Present width between groins.	Area at low tide between groins after contraction.	Area between groins, October, 1876.	Area between groins, October, 1877.	Area between groins, December, 1877.	Area between groins, March, 1878.	Greatest depth at low tide, March, 1878.	Locality.
	Feet.	*Feet.*	*Sq. ft.*		*Feet.*	*Sq. ft.*	*Sq. ft.*	*Sq. ft.*	*Sq. ft.*	*Sq. ft.*	*Feet.*	
35	950	11.2	6,296	June, 1876	595	4,876	6,300	6,564	6,223	6,263	12.1	Richmond Bar.
37	1,140	9.7	5,728	Oct., 1876	586	4,359	5,584	6,096	.....	6,168	12.3	Do.
39	1,205	9.2	5,799	....do	588	3,954	5,424	5,841	5,748	5,840	11.9	Do.
41	1,140	9.8	5,552	....do	600	4,307	4,907	5,824	5,720	5,846	12.7	Do.
43	1,020	12.2	6,201	....do	608	4,906	4,907	5,757	6,045	5,942	13.4	Do.
51	1,020	10.1	6,481	Sept., 1877	600	4,950	.....	6,181	6,635	6,727	14.0	Randolph Flats.
53	990	9.2	6,783	.. do	596	5,549	.....	6,295	6,510	6,589	14.6	Do.
55	995	10.0	6,513	... do	615	5,876	.....	6,290	.....	6,757	14.0	Do.
57	960	10.5	6,975	... do	610	5,643	.....	6,310	7,367	7,242	16.0	Do.
59	940	12.0	6,928	....do	644	5,792	.....	6,391	.....	7,502	15.4	Do.

From this the following averages are obtained:

	Area of whole river at low tide in 1874.	Area between groins after contraction at low tide.	Present area between groins at low tide.	Per centum of area cut off by works.	Per centum of enlargement between groins since contraction.	Per centum of present area between groins over whole river in 1874.
	Sq. ft.	*Sq. ft.*	*Sq. ft.*			
Richmond Bar	5,916	4,480	5,960	32	33⅓	1
Randolph's Flats	6,733	5,562	6,984	21	25⅛	3½

That is, although the low-tide areas of 1874 were afterward contracted from 20 to 30 per cent. by the works, yet the present areas between the works, or between the lines of contraction, are from 1 to 4 per cent. greater than the areas from shore to shore in 1874, and the slight changes which are found after freshets, as the cross-section approaches its former area, gives a color of probability to the opinion that these are the areas necessary for the river with its present slope; and, admitting this, we may hope that by further contraction, based on these normal areas, any reasonable depth of channel may be had and maintained.

On this supposition, a further contraction of about 100 linear feet on Richmond Bar should give 15 feet depth at low tide, and a less amount suffice on Randolph's Flats.

The plan for contracting the width recently pursued has been by means of timber groins, built generally at right angles to the current and to the level of mean high tide. These are lines of sheet piling supported by round piles at intervals of from 5 to 10 feet. The timber-work is revetted with the hard material dredged from the channel, which is dumped on the groins and allowed to find its own slope.

It is a cheaper plan than that of dikes parallel to the current, although probably not so effective. It affords a means of correcting the lines of contraction from time to time, as the groins may be increased in length or shortened, as circumstances require, whereas the case of a dike parallel to the current in the wrong place can only be remedied by another parallel to it. But, in addition, as the chief scour near Richmond is due to freshets and not to tidal actions, it would be necessary to connect such parallel dikes with the shores by just such groins at intervals, not only to confine the current, but to protect the dikes from scour in the rear. When the proper width for the river is found, it will doubtless be better to connect the outer ends of these groins by a dike, at least on the concave sides.

PRESENT CONDITION OF THE CHANNEL.

The depth on Rocketts Reef remains essentially as in June last, at 14.2 feet at *high tide*, and this is all that can be carried to the wharves above with safety. Some im-

provement was made in the width by the removal of 640 cubic yards of rock, but there is no continuous improvement in depth. Below this reef there are 16 feet depth at mean high tide, except for short distances opposite the lower end of Drury's Island and in Richmond Bar, where, at the date of this report, there are scant 15 feet. A channel through these shoal spots would cost very little; but experience teaches that a channel dredged in this part of James River, in sand or other light material moved by freshets, will be filled by succeeding freshets, unless a corresponding contraction of the water-way is made, and with such contraction no dredging is required.

SURVEYS.

The survey of the shoal in Kingsland's Reach, 10 miles below Richmond, made last summer, showed an improvement in depth, as compared with 1874, although no work had been done there. The November flood changed this condition, as before stated. A recent but not thorough examination indicates that the shoal is again being reduced in the main, but the channel dredged last December has shoaled about a foot, and has but 16 feet at high tide.

A survey of the river for two miles below Dutch Gap Cut-off, including the Varina Shoal, was made in November. It was made to ascertain not only the condition of the shoal, but if the regimen of the river had been changed by the action of the cut-off. It should have included a mile of the river above, and the bend cut-off, and a longer distance below. The November flood has occurred since, and a new survey would perhaps give more reliable information. In the preceding great flood of 1870 the cut-off was in nearly the condition it was left at the close of the civil war; a low causeway had been made across the upper end, and this was washed out by that flood. Soon afterward, and before the survey of 1874, the cut was widened and deepened, and in 1875–'76 it was again enlarged, and is now about 180 by 15 feet at low tide, with an area in cross-section of about 2,450 feet. By the recent survey there seems to have been no marked change in the depth of the river for two miles below since the survey of 1852–'53. There has been a scour for about 600 feet immediately below the cut-off, the depth being now from 35 to 40 feet. From that to Varina Shoal, one mile below, the depths correspond closely with those of the old survey, and range from 43 feet to 18 feet in the channel at low tide. The upper 18-feet contour on the shoal appears to be 200 feet lower down, the length between the upper and lower contour being nearly the same. The least channel-depth over the shoal is 15 feet at low tide, the same as in 1852–'53, but the width of the channel is probably less. It is not easy to get an accurate measurement of area in cross-section from the Coast Survey chart, since the lines of soundings are not at right angles to the current. The results of the examination are, however, submitted for whatever they may be worth, in the following statement:

No.	Position.	Area, 1852–'53.	Area, 1874.	Area, 1877.
		Square feet.	*Square feet.*	*Square feet.*
1	300 feet above outlet of Dutch Gap Cut-off	13, 940	12, 700	11, 057
2	800 feet below outlet	17, 250	15, 308	15, 092
3	1,000 feet below outlet	14, 500	*16, 610	15, 730
4	2,800 feet below outlet	14, 810	.....	14, 117
5	4,600 feet below outlet	14, 630	.....	15, 026
6	6,600 feet below outlet	14, 409	.....	14, 275
7	7,200 feet below outlet	14, 193	.....	14, 202
8	7,800 feet below outlet	16, 375	.....	14, 706
9	10,000 feet below outlet	*17, 284	.....	16, 068

* End of survey.

The lengths of Varina Shoal by the survey of 1852–'53 and of 1877 are as follows:

	1852–'53.	1877.
Less than 18 feet at low tide	3, 000 feet.	2, 950 feet.
Less than 17 feet at low tide	2, 700 feet.	2, 500 feet.
Less than 16 feet at low tide	1, 600 feet.	2, 000 feet.

As affecting the navigation for two miles below at least, the cut-off seems to have done very little beneficial or otherwise; an examination of the bend cut-off will probably show that its cross-section is reduced.

A survey of Harrison's Bar and of the shoal ground between it and Westover Wharf was made in November and December. On the bar the lines of soundings were taken 100 feet apart; elsewhere about 200 feet. There were formerly two navigable channels over this bar, separated by shoal ground. The southern channel has partially filled and is rarely used, then only by small vessels. As this ground had been recently gone over by the Coast Survey, and the object of our examination was only to get more minute information with a view to the improvement of the main channel, this southern channel was not examined. There has been some improvement in the depth of the

main channel since 1853, or rather the crest of the bar is narrower than it was. The shoal lying between the two channels is 2 or 3 feet higher than then, and is bare in places at very low tides. The following amounts of material must be removed to give—

	200-feet channel.	300-feet channel.	500-feet channel.
	Cubic yards.	*Cubic yards.*	*Cubic yards.*
18 feet at mean low tide	23,000	40,000	66,000
18 feet at mean high tide	3,520	9,000	13,000

As the removal of this material, at least of the larger amounts, could now be contracted for at 20 cents a cubic yard or less, the reduction of the bar is not a serious matter. If thought advisable, the southern channel could be closed by sheet-piling revetted with the dredged material. It is not unlikely that training-dikes will be needed in places to aid in maintaining the channel when dredged.

TIDES.

The two registering gauges were removed in the November flood and have not been replaced. Since then the day tides only have been observed. In reducing the observations from the *registers* the *high tides*, due to strong winds or to freshets, are excluded when they exceed the mean 1½ feet. The observations from the ordinary gauge made since November are all included in getting the mean. The observations from June, July, and August are the first that have been made during those months with the registers, and during this period the river was lower than it had been for many years.

Mean of observations on tides at Rocketts and Richmond Bar, June to November, 1877.

	Limitidal interval.		Duration.		Height above zero.		Rise and fall.		
	High tide.	Low tide.	Flood.	Ebb.	High tide.	Low tide.	Max.	Min.	Mean.
	h. m.	*h. m.*	*h. m.*	*h. m.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Rocketts Reef	16 44	24 09	5 05	7 22	3.463	—0.402	4.96	2.19	3.865
Richmond Bar	16 37½	23 53	5 13	7 14	3.396	—0.459	4.92	2.34	3.855

Mean heights of high and low tides and of rise and fall at Rocketts, and of the fall at low tide from Rocketts to Richmond Bar, a distance of 2½ miles, from April to November, 1877.

[From registering tide-gauges.]

	High tide above zero.	Low tide above zero.	Rise and fall.	Fall at low tide from Rocketts to Richmond Bar.
1877.	*Feet.*	*Feet.*	*Feet.*	*Feet.*
April	3.953	1.022	2.931	0.342
May	3.542	0.297	3.283	0.386
June	3.282	—0.567	3.847	0.109
July	3.234	—0.829	4.062	0.048
August	3.512	—0.482	3.944	0.031
September	3.656	—0.202	3.854	0.016
October	3.621	0.002	3.618	0.138
November	3.559	—0.088	3.654	0.096

The mean height of high tide above zero, not including June, July, and August, as heretofore found, is 3½ feet. It will be seen from the above table that as the fresh water decreases in volume as indicated by height of low tide, the tidal range or rise and fall is increased, so that in July, while low tides averaged 0.829 foot below zero, the high tides were only 0.266 foot under mean high tide. The fall from Rocketts to Richmond Bar when the river is low is almost nothing at low tide; at from 2 to 5 hours after high tide on calm days in June and July, 1877, the fall was 0.27 foot. In the

freshets of October and November the greatest fall in this distance was found to occur before the extreme height was reached.

	Height, feet.	Fall, feet.
October 5, greatest fall at 12 m	12.84	2.02
October 6, greatest height 11 a. m	13.83	1.64
November 10, greatest fall at 4 p. m	10.51	1.76
November 11, greatest height 1 a. m	11.00	1.63
November 25, greatest height	28.62	2.72

The greatest fall in the last case cannot be ascertained.

The day-tides at Rocketts, from December to May inclusive.

	December, 1877.	January, 1878.	February, 1878.	March, 1878.	April, 1878.	May, 1878.
Mean of high tides above zero in feet	3.43	5.04	4.68	3.97	4.03	4.31
Mean of low tides above zero in feet	0.23	3.02	2.52	1.32	1.09	1.79
Mean rise and fall	3.20	2.02	2.16	2.65	2.94	2.32

ESTIMATED COST OF COMPLETING THE WORK.

The amount expended on the improvements since the estimate of June 1, 1877, was submitted is comparatively small. The flood of November made changes in the channel sometimes for the better and sometimes for the worse; it caused loss and damage to plant and works, and showed that more work would be required at some points and less in others than had been estimated for. A revised estimate is therefore needed. In the absence of full information at this time, especially below Warwick Bar, this is impracticable. It is not improbable that the changes in plan required will not cost more than the amount expended during the year, and the former estimate is submitted without alteration. This estimate includes the river from Richmond to Harrison's Bar, with a provisional estimate for the latter. There are also three shoals lower down which need improvement, which have not been included in previous estimates.

Assuming that the prices for labor and material remain as at present, and that full appropriations are made so as to avoid the increase in expense due to incomplete operations, the amount now required to make a channel 18 by 180 feet at high tide, from Richmond to the lower end of Harrison's Bar, is $258,024.

The city of Richmond, by the loan of machinery and in actual work, has borne the greater part of the expense of carrying on and maintaining the improvement during the year. The city committee expended about $22,000, and furnished the United States 3 dredges, 2 steam-tugs, a steam dumper, a pile-driver, and 9 scows, at a rental not to exceed the cost of ordinary repairs.

COMMERCIAL STATISTICS.

The report of the James River Improvement Committee of Richmond, R. E. Blankenship, esq., chairman, dated February 21, 1878, says:

"The commerce on the river is steadily increasing. Larger vessels are seeking cargoes here. The improvement is gradually being understood, and in a short time will be as well known to shipmasters and merchants as the Clyde and other great thoroughfares that have been made by careful and intelligent engineering.

"The number of vessels arriving and departing from this port was 1,473, say, steamers 570, sail 903. Of this number vessels carrying 175,435 tons entered at Chesapeake and Ohio Railroad wharves, and vessels carrying 50,096 tons at Richmond and Danville Railroad wharves, a decided increase in the business of both railroads."

The following is from a letter of Dr. C. S. Mills, collector of this port:

"I herewith furnish a statement of revenue collected from customs at this port from June 1, 1877, to May 31, 1878, inclusive; also, a list showing the number and tonnage of all vessels which have been entered and cleared, together with a statement of the value of the foreign imports and exports.

"The list of vessels, however, does not include some eight hundred trading coastwise, nor the value of their cargoes, of which no record is kept in this office, such not being required to enter and clear.

"A statement is also furnished showing the extent and value of the direct foreign trade with this port and the various countries to and from which shipments are made.

"It will be seen that Richmond, in common with all other ports in the country, has suffered from the general depression of business and diminution of importations, but

I think we are beginning to realize some of the benefits promised from the improvement of the James River in the increased tonnage of the vessels trading with this post, many of which, formerly compelled to transfer to lighters portions of their cargoes before coming up to Richmond, can now arrive at our wharves with full cargoes, thus avoiding the delay and expense of transhipment.

"Very respectfully yours,

"CHARLES S. MILLS,
"*Collector.*"

IMPORTS.

	Value.	
From England	$20, 735	
From Nova Scotia	6, 676	
From New Brunswick	926	
From Brazil	172, 916	
		$201, 253
Dutiable imports	21, 917	
Free	179, 336	
		201, 253

EXPORTS.

To England	$270, 236	
To Ireland	19, 500	
To Austria	203, 000	
To Brazil	1, 110, 534	
To Denmark	45, 530	
To France	257, 950	
To Germany	266, 552	
To New Brunswick	338	
To Cape Town, Africa	31, 622	
To Holland	32, 400	
To Cuba	29, 130	
To Norway	76, 735	
To Italy	154, 812	
To Nova Scotia	2, 376	
		2, 500, 715

ENTRANCES AND CLEARANCES AT THE PORT OF RICHMOND, VIRGINIA, FROM JUNE 1, 1877, TO MAY 31, 1878.

Coastwise steamers.

	Vessels.	Tonnage.
Entered	433	439, 724
Cleared	515	479, 341

Coastwise sail vessels and barges.

Entered	122	24, 689
Cleared	16	2, 478
Entered barges	3	257

FOREIGN TRADE.

Sail vessels.

"Entered: vessels, 38; tonnage, 9,427; value of cargoes, $201,253. Cleared: vessels, 96; tonnage, 29,727; value of cargoes, $2,500,715.

"Total amount of customs collections at port of Richmond, Va., from June 1, 1877, to May 31, 1878, $15,067.85."

Very respectfully, your obedient servant,

H. D. WHITCOMB,
Assistant Engineer.

Capt. C. B. PHILLIPS,
Corps of Engineers, U. S. A.

F 5.

IMPROVING APPOMATTOX RIVER BELOW PETERSBURG, VIRGINIA.

The balance ($15,000) of the appropriation of August 14, 1876, was made available May 1, 1877.

A project for the expenditure of this balance was submitted to the Chief of Engineers on the 16th of July, 1877, and was by him approved. The project contemplated the expenditure of this entire balance upon that portion of the river between the upper end of Puddledock Cut and the city of Petersburg, the work to consist of the removal by blasting of about 400 cubic yards of rock from the channel at the bend opposite Stein's Upper Cut, the construction of about 1,000 linear feetof longitudinal dike extending downstream from Lieutenant's Run, and the construction of 13 wing-dams, consisting partly of sheet piling and partly of stakes and brush wattling, and located for the most part at the long, straight reach occupied by Page's Bar.

This portion of the river had necessarily been somewhat neglected of late years, the greater portions of the appropriation having been absolutely required at the lower portions of the river, including the dredging of Puddledock Cut and the construction of deflectors and embankments in connection with it.

The details of the work were determined upon after a careful study of the past history of the improvement and after forming certain deductions from current observations taken for the purpose.

In May, 1877, current-observations were taken at two points, one near the "magazine" rock in the bend of the river opposite Stein's Upper Cut for the purpose of determining the proper location of the channel at this point; the other opposite the city of Petersburg, for the purpose of determining the discharge of the river. The observations at the magazine rock showed conclusively the impracticability of turning the channel to the south of the rock, and as the space was extremely limited between it and the northern shore, it was determined to remove by blasting so much of the rock as would give a clear passage of 100 feet. A sketch showing the original location of this rock, together with the paths of floats before its removal, accompanies this report.

In taking observations for discharge, a point was selected at the lower end of the city of Petersburg where the river is nearly straight.

A base line, 150 feet in length, and parallel to the general thread of the stream, was laid out on the northern shore, from which base the floats were located and timed while on their passage.

Four gauges had been previously located and connected with a line of levels, one at the point of observations, the others at intermediate points between Petersburg and the upper end of Puddledock.

These gauges were observed during the whole time that observations were being made. The observations were necessarily limited to a single day, but were continuous during an entire period of ebb and flow. Sixty-six observations were made in all, covering quite thoroughly the entire stream both horizontally and vertically. The river at the time the observations were made was at about its ordinary stage.

It was found that the mean discharge of the river at the point selected during the entire period of ebb tide was at the rate of 1,074 cubic feet per second, the mean velocity being .78 foot per second, or .53 mile per hour.

The present area of cross-section at the point of observations is 1,377

square feet. An amount of dredging has been done here, however, by the city of Petersburg of late years, and from an old map made before the dredging was done, the old area of cross-section is found to have only 1,080 square feet.

Considering the nature of the bottom, being composed mostly of quite coarse sand, and the present mean velocity of the stream being but a trifle over one-half a mile per hour during ebb at the straight portions of the river, it is to be considered that the gradual filling of all dredged straight portions of the river will continue until the original area of cross-section shall have been restored. It seemed evident, then, that a general contraction of the stream was called for by means of longitudinal dikes and perpendicular jetties, in order to maintain a greater depth of water than the natural width of the river and the ordinary supply of water would allow.

A depth of 10 feet at ordinary low water is extremely desirable below the city of Petersburg, and with this desired depth in view, it was found by the application of the most approved formula that the river should not have a greater general width than about 125 feet along the straight reaches.

With this conclusion in view the details of the longitudinal dike and the perpendicular jetties were arranged, although in the case of the latter they were extended so as to contract the stream to only 140 feet in width. This for the reason that as only the alternate jetties could be fully completed for want of funds, the river was left at this width, that a study of the effects of the jetties thus extended could be made. If necessary, as will probably be the case, the extension of the remaining jetties will be greater, so as to contract the river to 125 or 130 feet in width.

A dredge and 4 decked scows were chartered, and on the 26th of July, 1877, commenced removing loose rock and coarse sand and gravel overlying the solid rock to be blasted.

The dredge was afterward chartered from time to time as needed, to continue this process and to remove small pieces left by the diver. The rock-machinery belonging to the James River improvement was brought over for use here, and drilling was commenced on the 5th of August.

Drilling and blasting were continued until the 9th of November, 1877, during which period 421 cubic yards of rock were removed and deposited on the neighboring bank to be afterward used as riprapping.

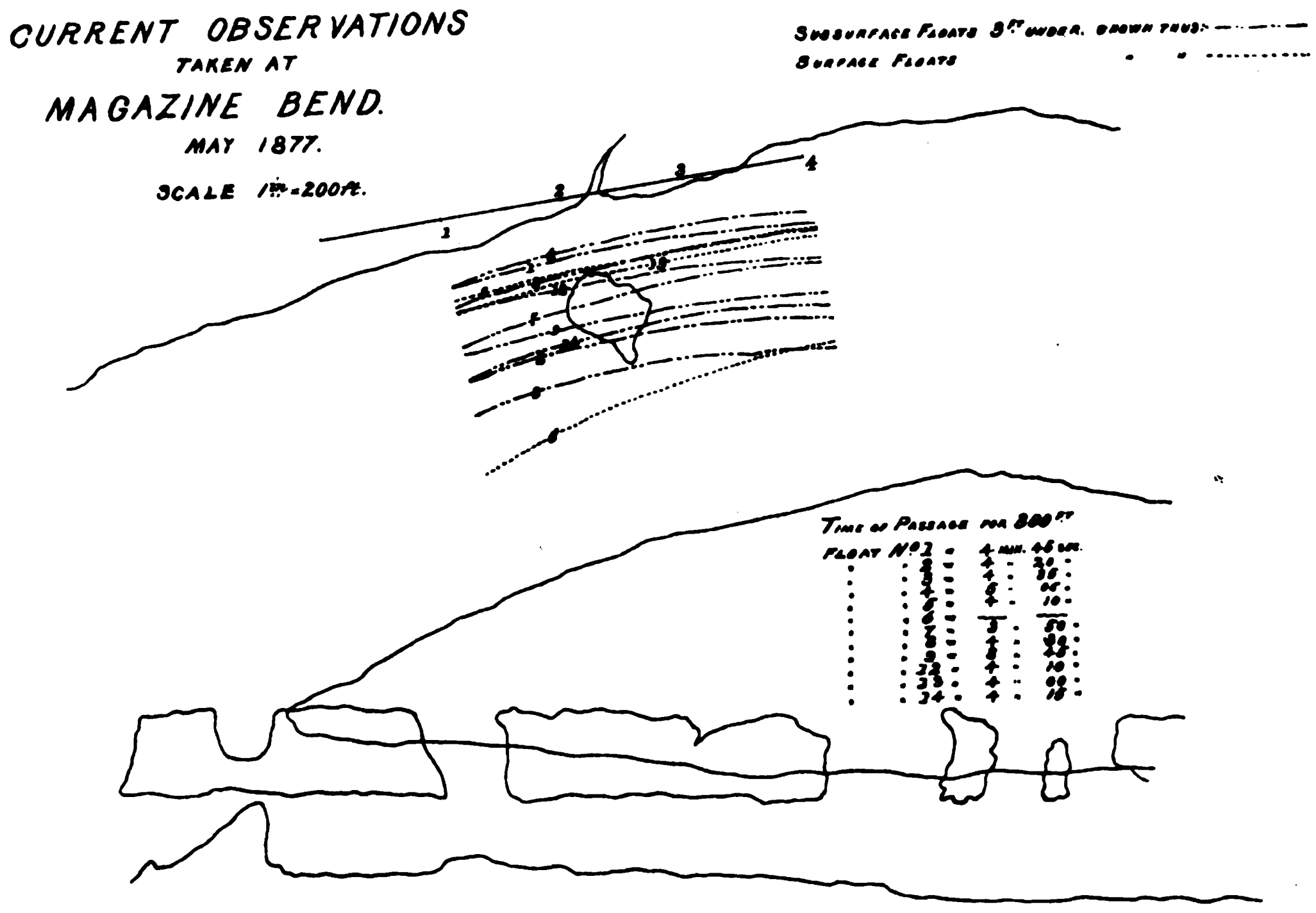
Meanwhile, the construction of the longitudinal dike on the south shore and the brush jetties at Page's Bar was going on.

The dike was commenced in September, 1877, and completed early in January, 1878. The dike is sheet-piled, is 812 feet in length, and serves the purpose of turning toward the main channel the water which has heretofore escaped through Stein's Upper Cut, and also diverts the water of Lieutenant's Run so as to discharge behind the dike instead of as formerly directly into the channel.

The jetties were commenced in August, 1877, and work was continued upon them until the 13th of March, 1878, when all work was suspended for want of funds. During this period 2,249 linear feet of stake and brush work, and 437 linear feet of sheet-pile work had been completed.

The above aggregates are divided up among 13 perpendicular jetties, all of which project from the northern shore and reduce the general width of the river along Page's Bar to about 140 feet.

The sheet-pile work is all located at the outer ends of these jetties, for the protection of the brush-work nearer the shore. Only the alter-


CURRENT OBSERVATIONS
TAKEN AT
MAGAZINE BEND.
MAY 1877.
SCALE 1in.=200ft.
SUBSURFACE FLOATS 3ft UNDER. SHOWN THUS:
SURFACE FLOATS
TIME OF PASSAGE FOR 800ft
FLOAT No. 1 = 4 MIN. 45 SEC.
2 = 4 " 20 "
3 = 4 " 35 "
4 = 5 " 05 "
5 = 4 " 10 "
6 = 3 " 50 "
7 = 4 " 30 "
8 = 5 " 45 "
9 = 4 " 10 "
22 = 4 " 00 "
23 = 4 " 15 "
24 = 4 "

nate brush jetties are thus protected by sheet piling. All operations except occasional soundings have remained suspended since the 13th of March last.

Mr. H. D. Bird has continued as heretofore the resident engineer at Petersburg. His report is appended hereto.

An appropriation of $30,000 was made by the act of June 18, 1878, for the fiscal year ending June 30, 1879; $83,000 were required to complete the project which was in existence on June 30, 1875; $53,000 yet remain to be provided for.

Money statement.

July 1, 1877, amount available	$15,571 09	
Amount appropriated by act approved June 18, 1878	30,000 00	
		$45,571 09
July 1, 1878, amount expended during fiscal year		15,565 90
July 1, 1878, amount available		30,005 19
Amount (estimated) required for completion of existing project		53,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		30,000 00

REPORT OF MR. H. D. BIRD, ASSISTANT ENGINEER.

PETERSBURG, VA., *May* 31, 1878.

CAPTAIN: I have the honor to report to you the progress of the Appomattox River improvement for the last fiscal year.

Owing to the limited means at our disposal the amount of work done was light and of a desultory character. Still it was of importance toward furthering the construction of the improvement.

We began the year by completing an embankment we had been at work on at the close of the last year to secure Puddledock Cut from damage by freshets. This embankment is 6,428 feet long, 8 feet wide on top, and 5 feet above high water.

It is interesting to remind you that the dredging of this cut was completed in August, 1876, and the south channel below in June, 1873, nearly 4 miles of the 6 miles of river that needed improvement. Since those dates there have only been taken out 15,344 yards in all to maintain the depth of channels, to which they had been dredged. This amount of repairs is comparatively light, and I think it shows conclusively that when the improvement is completed and the banks secured according to the plan of the engineer in charge, the cost of repairs will be lighter.

In July last we commenced with the dredge uncovering a ledge of rock in the river just below Petersburg, for the purpose of widening the channel through it. We blasted out and landed 421 cubic yards of granite and made the channel 100 feet wide and 10 to 12 feet below low-water.

During the progress of this work we commenced about one-half mile down the river, and nearly completed a number of transverse jetties made with posts and a wattling of poles to contract the channel.

Their united length is 2,249 feet, and they extend a distance of 3,000 feet down the river. As these jetties reached deep water we continued their extension with sheet piling far enough out to obtain the necessary contraction of channel; and up to the time the funds were exhausted we had constructed 437½ feet of this piling; we also built a longitudinal line of the same kind of piling 812 feet long to guide the current round a bend of the river, where the shore was too low for the purpose. As the water was occasionally too high to work all day on the piling, the hands were usefully employed breaking the rock got out into riprap; and particularly in digging and securing a new outlet for Lieutenant's Run. This stream, which in freshets used to bring down and empty large quantities of sand in the harbor, is now carried behind the longitudinal piling and deposits the sand on the flats below, while the water runs into the river in a line parallel to the current.

All the work of this year was done by hired labor, except the driving of piles, which was let to contract. The blasting of rocks was done with machinery belonging to the government. They were worked by skilled men hired for the purpose. The superintendent who managed them also manufactured the nitro-glycerine used in blasting. The other portions of the work, including the carpenters' work of piling, were put up by ordinary laborers, under the management of the inspector of dredging. I have

appended to this report a statement of the cost of each piece of work that could be averaged to show that it was economically done, and I can vouch that it was well done.

Respectfully, your obedient servant,

H. D. BIRD,
Assistant Engineer.

Capt. C. B. PHILLIPS,
Corps of Engineers, United States Army.

STATEMENT OF THE COST OF THE DIFFERENT PIECES OF WORK DONE THIS YEAR IN WHICH THE AVERAGE COST PER YARD OR FOOT COULD BE ASCERTAINED.

Blasting, hoisting, and landing 421 yards of rock:		
Wages of men	$2,997	16
Materials used, repairs, &c	583	93
Average per yard is $8.50	3,581	09

This does not include the cost of uncovering rock or machinery used.

Building 2,249 feet of jetties, posts, wattling-poles, and labor:		
Labor	$607	80
Materials, &c	501	86
Average cost per foot, 49 cents	1,109	66
Extension of jetty piling, 437½ feet:		
Labor and hire of scows	$180	30
Materials	936	41
Driving 437½ feet piles	437	50
Average cost per foot, $3.57	1,554	21
Longitudinal piling, 812 feet long:		
Labor	$394	30
Materials, &c	1,300	09
Driving piles	812	00
Average cost, $3.08 per foot	2,506	39
Breaking 180 yards of rock into riprap:		
Labor	$81	72
Tools (less value on hand)	3	15
Average cost per yard, 47 cents	84	87

NOTE.—There is a considerable discrepancy between the average cost per foot of longitudinal piling ($3.08 per foot) and jetty piling ($3.57). The difference was mainly caused by the difference in the quality of sheet piling used. Common lumber was used in the longitudinal piling, and the best heart pine in the jetty piling, as a more durable timber was needed there.

COMMERCIAL STATISTICS.

PETERSBURG, VA., *September* 19, 1878.

DEAR SIR: As an appendix to my report of the work done on this improvement during the last fiscal year, I desire to report to you the following information in regard to the business of this city.

The collector of internal revenue for this district reports that he collected during the last year $1,136,621.05.

The collector of the port reports:

The number of vessels that entered coastwise	430
The number that cleared	340
The number of foreign vessels that entered and cleared	4
	774

In connection with the port collector's report, I desire to say that his statement of the small number of vessels that resort to our river is no criterion of the commerce that will seek our port when our improvement shall have been completed. City Point (the port of Petersburg before the war) was the point of shipment of all the coastwise trade that passed through the city; and the city authorities were then engaged in improving the navigation of the river to bring large vessels up to the wharves. But during the war the river was dammed up and it reverted to its former shallow state.

The completion of the improvement will remedy this evil; and if the same depth of navigation be given Petersburg as is contemplated to be obtained in Richmond, it will make our port fully equal to that; and as its connections with the interior are more extensive than that of Richmond, with the further advantage that it is nearer the sea, there is no good reason that its commerce should not increase by giving it equal facilities.

But the large amount of internal revenue paid is a better indication of the importance of the business of Petersburg; and not only that, but it forms a direct claim upon Congress for its most liberal consideration of the wants of our improvement, which it is believed no other city of equal size in the Union can offer.

Respectfully, your obedient servant,

H. D. BIRD,
Assistant Engineer.

Col. WM. P. CRAIGHILL,
Major of Engineers, U. S. A.

F 6.

IMPROVEMENT OF THE GREAT KANAWHA RIVER, WEST VIRGINIA.

The sites for a new lock and dam, to be designated as No. 3 of the Kanawha series, were acquired during the autumn of 1877. The lock is to be located upon the right bank, at the foot of Paint Creek Shoal, and is designed, in conjunction with the two locks below, to furnish navigation throughout the year from Cannelton to the Charleston Pool. The work at lock No. 3 is being carried on by hired labor, and the purchase of material in open market.

Work was commenced in February last, and at the date of this report quarries have been opened, tramways to the site graded, and about ¼ of the coffer-dam placed in position.

At lock No. 4, near Cabin Creek Shoal, Mr. C. McCafferty has continued work for construction of same under contract dated October 15, 1875. The financial difficulties of the contractor caused the work to progress but slowly during the fall of 1877.

Obtaining assistance in February last his work has since progressed more favorably, and at this time the prospect is that his work will be carried successfully to completion by the first of September next.

At dam No. 4 Messrs. Freeman, Richardson & Fraser have utterly failed to carry out their contract dated May 1, 1877, for the construction of a dam abutment, pier, and floor of a navigation pass adjoining lock No. 4. In November, 1877, this firm had nearly completed the abutment, and had commenced placing coffer-dam for the pass, but they became financially embarrassed and discouraged by frequent freshets, and finally abandoned their work on the 19th of December, 1877. Their contract was annulled on the 31st of January last, and the work has since been carried on by hired labor, and the purchase of material in open market. At this date much of the necessary machinery has been purchased by the United States; rights of way and buildings have been secured; a large quantity of stone has been cut; and dredging at site of coffer-dam at pass has been commenced. A contract was made February 4, 1878, with Messrs. Ramsay & Latrobe for the iron work of the pass and weir of dam No. 4.

At lock No. 5, near Brownstown, Messrs. D. M. & C. P. Dull continued construction of same, under contract dated August 20, Occasional strikes of the contractor's laborers have delayed the somewhat, but it has on the whole progressed favorably, and the cations are that it will be entirely completed by 1st of September

A contract was made May 7, 1878, with the Edge Moor Iron Com for the construction of iron gates for lock No. 5.

At dam No. 5, Mr. J. H. Shultz has continued work for constru of dam-abutment, pier, and floor of navigation-pass adjoining lock N under contract dated March 28, 1876.

The masonry of the abutment had all been laid at the date of the annual report.

The pier was completed, and dredging for coffer-dam of pass menced, in September, 1877.

The work of placing coffer-dam of pass has progressed but sl owing to freshets during October and November, 1877, and financia ficulties of the contractor in the spring of 1878. At the date of report, the raising and embanking of the coffer-dam is still in prog

The iron-work of the pass and weir (contract of Mr. W. M. Ar dated May 23, 1877) has all been delivered at the site.

Limited operations of a temporary character at points not aff by the permanent works have been carried on during the year. Du September, 1877, a crane-boat was engaged in removing bowlders at portion of the river between Knob Shoal and Emory's Dam, a dist of about 6 miles. The freshet of November 24–27 caused a break a 75 feet in length in "Two-mile Dam."

Steps were at once taken to repair damages by filling in with s quarried and placed by hired labor. This work, which was suspe during the winter months, was resumed last spring, and at the da this report is nearly completed.

A survey of the Kanawha River, below Charleston, as well as sur of portions of Coal and Pocatalico Rivers were made during the with a view to establishing the proper locations of locks at the lowe tion of the river.

The state of the river has been much more favorable for succe operations during the fiscal year just ended than during the pre year.

The working season of 1877 was until October unusually favor

During the month of June last labor troubles seriously interfered operations at all the works on the river.

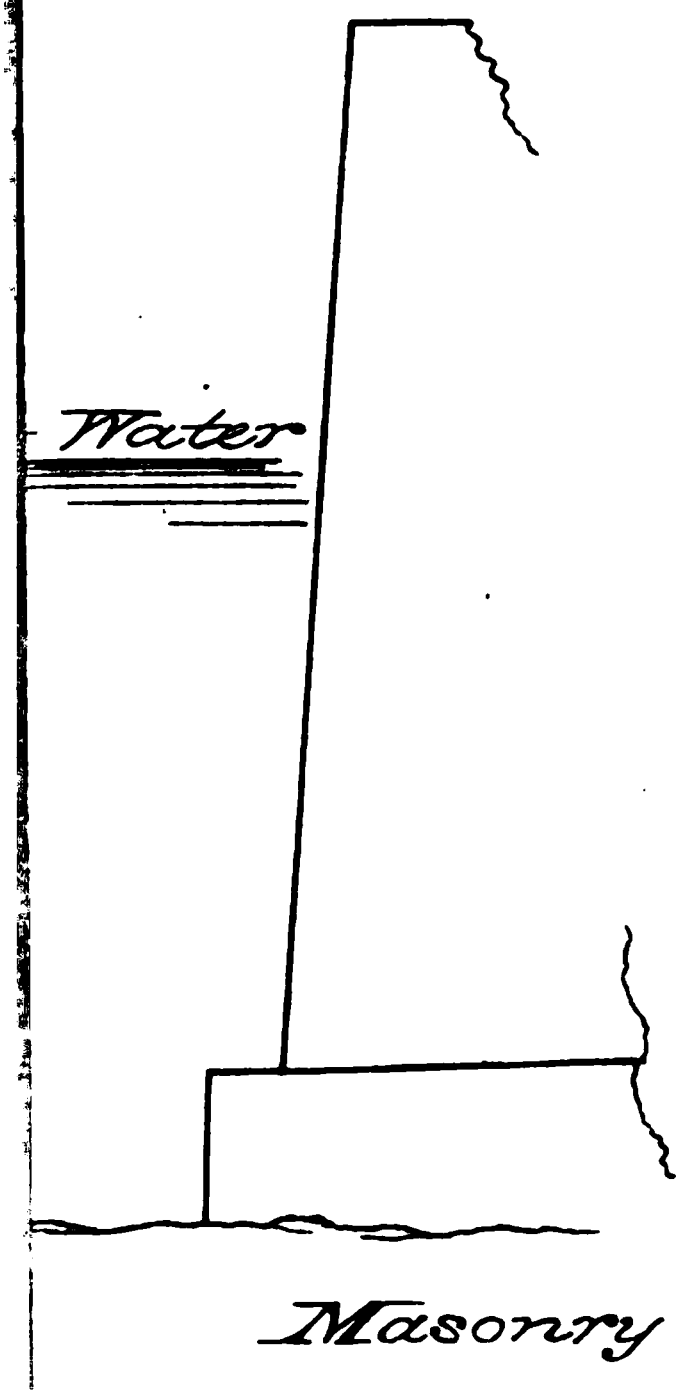
These troubles originated at lock No. 5, where the contractor's l ers struck for higher wages. The strikers sent committees to the works on the 20th of June, and induced many of the contractor's l ers to join them, the government workmen refusing so to do. On 23d a mob organized at Brownstown and, proceeding up the river, ca by threats, all laborers and mechanics to cease work.

Government workmen resumed work on the 28th of June, but strike at lock and dam No. 5 still continues at this date.

The details of the operations of the fiscal year are fully set fort the accompanying report of Lieut. Thomas Turtle, Corps of Engin who has remained the resident engineer in immediate supervision o work.

Mr. W. R. Hutton has continued during the year, by constant co ence, aid, and advice, to give the work the benefit of his extensive fessional knowledge and experience.

Mr. A. M. Scott has also been constantly and efficiently engaged


Water
Masonry

the permanent works, as well as upon special surveys and examinations which have been and will from time to time become necessary.

The appropriations have been: March 3, 1873, $25,000; June 23, 1874, $25,000. Expended in temporary improvement, March 3, 1875, $300,000; August 14, 1876, $270,000; June 18, 1878, $222,000. The total of the estimate for the permanent improvement was $4,153,000, but it is believed the work can be done for considerably less, as the estimate was full, and the contracts thus far have underrun the estimates.

Money statement.

July 1, 1877, amount available	$447,584 64	
Amount appropriated by act approved June 18, 1878	222,000 00	
		$669,584 64
July 1, 1878, amount expended during fiscal year	189,700 70	
July 1, 1878, outstanding liabilities	19,803 43	
		209,504 20
July 1, 1878, amount available		460,080 44
Amount (estimated) required for completion of existing project		3,360,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		500,000 00

Proposals for iron-work of dam No. 4, Great Kanawha River, opened at 12.5 p. m., February 1, 1878.

No.	Name.	Residence.	Price.
1	S. Wilson Murry	Milton, Pa	$14,475 00
2	W. Bollman	Baltimore, Md	23,872 00
3	Wilcox, Shinkle & Miller	Pittsburgh, Pa	18,200 00
4	Edge Moor Iron Company	Edge Moor, Del	22,168 00
5	Lane & Bodley Company	Cincinnati, Ohio	21,000 00
6	W. M. Archer	Richmond, Va	15,314 40
7	W. D. Haven	New York	21,750 00
8	Ramsay & Latrobe	Baltimore, Md	12,995 00
9	Paulding, Kemble & Company	Cold Spring, N. Y	28,350 00
10	Poole & Hunt	Baltimore, Md	22,160 00
11	Reading Iron Works	Reading, Pa	21,871 00

Contractor, Ramsay & Latrobe, at $12,995.

Abstract of proposals for iron gates for lock No. 5, Great Kanawha River, opened immediately after noon, April 24, 1878.

No.	Name.	Address.	Price.
1	Carroll & Company	Pittsburgh, Pa	$24,582 00
2	W. Bollman	Baltimore, Md	21,492 00
3	J. R. Anderson	Richmond, Va	13,500 00
4	Riter & Conley	Pittsburgh, Pa	15,000 00
5	Edge Moor Iron Company	Wilmington, Del	10,000 00
6	William M. Archer	Richmond, Va	10,420 64
7	Ramsay & Latrobe	Baltimore, Md	18,485 00
8	Reading Iron Works	Philadelphia, Pa	18,043 82

Contractor, Edge Moor Iron Company, at $10,000.

REPORT OF LIEUTENANT THOMAS TURTLE, CORPS OF ENGINEERS.

CHARLESTON, KANAWHA COUNTY, W. VA.,
June 19, 1878.

CAPTAIN: I have the honor to submit the following annual report of progress in the improvement of the Great Kanawha River for the year ending June 30, 1878:

Mr. A. M. Scott is principal assistant engineer, and is superintending the construc

tion of locks and dams Nos. 4 and 5. He is assisted by Mr. McDermott, assistant engineer, in making estimates and drawings, and in giving lines and levels in construction.

Mr. E. H. Kirlin is inspector at No. 4, and Mr. J. H. Minnick is inspector at No. 5.

Mr. H. A. Baillie, assistant engineer, is superintending the construction of lock No. 3, and has under him Mr. Charles Humphreys, assistant engineer, whose duties are similar to those of Mr. McDermott, as above.

Mr. John S. Hogue had charge of the surveying parties in the field last year, and is employed mapping the river as surveyed, and in preparing such drawings as may be required.

Lock No. 3.

The site for this lock and dam was obtained in the autumn of 1877. Three tracts are included, two of which were obtained by condemnation and one by purchase. The latter belonged to Mr. J. G. W. Tompkins, and the two former to Mr. Justin Rideout and to the Chesapeake and Ohio Railroad respectively.

The lock is located upon the right bank, at the foot of Paint Creek Shoal, and with some dredging above will furnish with the locks below a continuous navigation throughout the year from Cannelton to the Charleston Pool.

This work is to be carried on by hired labor and the purchase of material. The preliminaries began in February, by the purchase of crib-logs for the coffer-dam and an examination for quarries. The opening of quarries began in March, and we now have a most promising chance for obtaining all the stone necessary for lock and dam, roughly estimated at 30,000 cubic yards. The necessary fencing has been made, and buildings provided; a road and tramways have been opened and graded, and a portion of the necessary machinery, flats, derricks, and tools have been obtained.

Dredging for the lock-site began in March, and was suspended by high water on April 26. To that time nearly 6,000 cubic yards were removed. Dredging was resumed on May 23. The placing of the coffer-dam began on June 10, and at close of this report is in progress (June 15, 1878).

Lock No. 4.

The progress made in the construction of this work at the close of the last annual report may be seen by reference to Appendix E of the Annual Report of the Chief of Engineers for 1877 (page 300, Part I).

At that time (June 16, 1877) the coffer-dam was pumped out and construction was in full operation. The season of 1877 was a most excellent one for the prosecution of the work, there being no interruption by high water till November 10, except from October 5 to October 9. Unfortunately the parties engaged in the construction became embarrassed financially, which crippled them very much throughout the latter part of the season. The first indication of the difficulties appeared in July, and matters became worse from month to month, till finally the machinery, tools, material, and property of all kinds belonging to these parties were levied upon by the sheriff, November 12.

This practically ended work for the season. On December 12 operations were resumed with a small force, which was employed irregularly and at intervals till February 25, when the contractor obtained assistance to carry on the work. Since that date the work has progressed favorably, and with good security that it will be carried successfully to completion. At the date of writing (June 10, 1878) the masonry is complete to the coping, and most of this is laid; the paving inside land-wall and between the wings is nearly all in place, and the slope-wall protection of the bank is in progress. To complete the contract the following work is yet to be performed, viz, placing cribs at head and tail of walls, paving back of cribs and that remaining between wings, some filling and grading of the bank, and the completion of the slope-wall protection. The whole will be completed probably before September 1.

Dam No. 4.

When the last annual report was rendered the excavation for the abutment had begun, and the timber for the first section of coffer-dam was in preparation.

The space for the abutment was inclosed on the river side by sheet planking, on the inside and outside of which material from the excavation was embanked. This was the only dam necessary to permit the inclosed space to be pumped out and the masonry to be laid therein. The delivery of stone from quarry to site began on June 28, and the laying of masonry in foundation commenced on August 23. The abutment was built ready to receive the coping on November 7. A rise in the river on November 12 washed away a great part of the filling within and behind the abutment. A portion of this was restored to prevent further cutting round the abutment by the river.

In the preparation of concrete stone for the foundation of the pass, one of Blake's

stone-crushers (old pattern) was used. In the quarry opened there was a stratum of very hard dark-colored stone, which crushed very well.

It was expected to complete the pass and weir with 3 coffer-dams, the first to include the pier and 120 running feet of the pass, the second to include the remainder of the pass (128 feet), and the third to include the entire weir. Drawings to illustrate the construction of the coffer proposed to be used by the contractors are submitted herewith.

Induced by the success attending the construction of the abutment of dam No. 5, where the water was kept out of the excavation by a simple embankment of the excavated material, the experiment was made of placing the coffer for this first section immediately upon the bottom of the river. The average depth of material overlying the rock within the area inclosed was, according to borings, made about $1\frac{8}{10}$ feet. Should experience show that the coffer could not be made sufficiently tight, a trench could be dredged outside the banking, then by filling this trench with proper material leaking could be prevented. Though the character of the filling and the quantity and kind of embankment placed on the outside permitted no sufficient test in the short time from the commencement of pumping to the breaking of the coffer by the rise of November 10, the experience was not such as to justify a repetition of the experiment in the future.

The delivery of the crib-timber for the coffer-dam commenced on June 22, the forming of the cribs began on July 18 and the placing of them on July 21. The placing of the coffer proper began on August 22, and the planking was completed on September 27.

On October 6 the river rose to 10.25 feet above low-water, and the coffer broke on the end next the lock and at the up-stream corner on the other end. Repairs began at once, and pumping commenced on October 29. Repairs to pump, leaks, rains, and high-water interfered with this operation, and on November 10 the lower side of coffer was washed out, taking the pump with it, the gauge reading 16.5 feet above low-water. Repairs again commenced, but a flood on November 24 and 25 suspended these repairs, and caused still further damage.

At this time the contractors gave out for the want of funds, and abandoned the work on December 19, their effects having been seized on the previous day. By the terms of the contract the coffer-dam became the property of the United States, and men were employed to remove and store such portions of the planking timber and rods as were in danger of loss.

It being evident from circumstances that the contractors had no intention to prosecute the works further, their contract was annulled on January 31, and authority was received to carry the works to completion by hired labor and the purchase of material in open market. Steps were taken accordingly, and derricks, flats, engines, &c., have been procured. The territory leased by Freeman & Co. for stone-yards, the rights of way obtained by them for the branch track to the Chesapeake and Ohio Railroad, and most of the buildings constructed by them for their operations, have been rented. Nearly 2,000 cubic yards of stone, including that for concrete, is now prepared on the site.

The removal of the wrecked coffer has been commenced. The coffer-dam for the lock is now of no further use, and the new coffer for the pass is to inclose the space next the lock. It is hoped that this first section will include at least 200 feet of the pass. Arrangements have been made for the material of this coffer, and the framing thereof is commenced.

A dredge is now upon the site, about to commence excavating for this first section. Operations being carried on simultaneously at three locks and two dams, at all of which dredging is necessary, the matter of dredges was a pressing one, the dredges heretofore available being only two in number. The matter was further complicated by the fact that if they were caught by the low-water season at the downstream works it might be impossible to transfer them to the other works till late in the season, and from the circumstances of the case the downstream works should suffer no interruption nor be delayed. By a fortunate suggestion of Mr. Scott, arrangements have been made with the Coal River Navigation Company by which we obtain the use of their dredge, supplying them with a hoisting-engine for the time, for which purpose only did they have use for their machinery. This is the dredge now in use at dam No. 4.

Lock No. 5.

The progress made in the construction of this lock at the close of the last annual report may be seen by referring to Appendix F of the Report of the Chief of Engineers for 1877 (Part I, p. 302). On that date (June 16, 1877) the coffer-dam was filled by a rise. Pumping was resumed next day. The coffer was again filled by a rise on June 30. Pumping was resumed on the 21st and masonry on the 23d. From that time till October 5 the work was uninterrupted by high water, except for but a couple of days.

On September 15 the construction was so far advanced that the coffer was no longer

necessary, and water was let in. On September 19 a dredge was put to work removing the lower end of the coffer to admit a flat-boat with a hoisting-engine and derrick, which was henceforth used to lay masonry and discharge stone from flats.

The flood of November 24 arrested the setting of stone till December 5. From this time throughout the winter a decreased force was employed whenever the weather permitted, and, as the winter was generally an open one, but little interruption was caused, except for about a week in January. Masonry was carried forward whenever the temperature permitted.

The season of 1878 opened early in March, and the work has progressed favorably since that time. At the writing of this report (June 14, 1878) the masonry of the lock is complete, except replacing a couple of coping-stones broken in doweling. The crib at the head of land-wall is in place, dredging for the crib at the tail of the land-wall is complete, and the framing of this crib is in progress; the paving back of the land-wall and between the wings and most of the slope-wall is laid; a portion of the riprapping for slope of bank is placed, and the removal of the coffer-dam is in progress. The work under this contract will probably be completed by September 1. The construction for the iron gates for this lock is now under contract.

DAM No. 5.

When the last annual report was rendered the masonry of the abutment was all laid, the filling and grading of the bank was in progress, the placing of the crib below the abutment was going on, and pumping in the coffer-dam for the pier was suspended by high water.

The filling and grading of the bank with the slope wall and riprap protection therefor, and the paving on abutment and back of crib are now practically complete.

It was found, when placing the crib below the abutment, that, in the time intervening between the dredging and settling the crib to place, a quantity of material, mostly sand, had slipped out of the bank, partially filling the excavation. The crib at this time was partially filled with stone. When the dredging was done a portion of the material was thrown on the outside, forming an embankment. This embankment was extended, inclosing the excavation, which was then pumped out. The stone filling was then taken out, and the sand, being removed from underneath the crib, permitted it to settle to rock.

In the autumn of 1877 a portion of the riprap protection, up stream from the abutment, was placed upon embanked material. Although this riprap was placed with care, the earth underneath was washed out to a considerable extent, and the riprap settled so that the work had to be gone over again. To prevent this in future the riprap placed this season has had a layer of shells and broken stone, 6 inches in thickness, placed underneath. In putting any more work out at contract it is recommended that this be provided for in the specifications.

The work of embanking around coffer for the pier was carried on from the time of the last annual report. On July 2 pumping was resumed. Leaks, repairs to coffer, breakages to pump, &c., hindered this operation, and it was only on July 28 that the laying of masonry in the foundation of the pier commenced. The pier was completed in September except that two coping-stones were left without mortar, to await the placing of the landing of the trestle-bridge for the weir, and that the landing for the trestle-bridge for the pass is not yet placed.

Dredging for the pass began on September 19, and the placing of the coffer-dam commenced on September 26. This work was suspended by the rise of October 6. It was resumed on October 15, and carried on till the rise of November 10 suspended operations for the season. The preparation of material for the resumption of work on this coffer began late in March, and on June 4 men were again put to work upon it, raising it and embanking around it. At the close of this report (June 15) this work is in progress.

The iron-work for the movable pass and weir, contracted for with Mr. W. M. Archer, of Richmond, Va., is delivered complete. A portion of the timber for the wickets is stored at the site, and arrangements have been made for the balance.

TEMPORARY IMPROVEMENT.

The crane-boat, with a crew of men, was set at work early in September removing bowlders from the shallows in the lower part of the river. Operations began at the head of Knob Shoal and had progressed as far as Emory's Dam, about 6 miles below, when a slight rise on the 15th suspended work. Rains upon the headwaters had made the river so muddy that obstructions could not be seen. The water receding and becoming clear an attempt was made early in October to resume, but the rise of October 5 suspended this work for the season. In the portion of the river gone over the work performed is of material benefit to the low-water navigation and to the "close towing stages" of the river.

In the flood of November 24–27 a break occurred in Two-Mile Dam near the bank, and about 75 feet in length, which endangered the whole dam, and the bank began to wash pretty badly. Steps were at once taken to repair the break by filling in with stone which were quarried and placed by hired labor. This work was interrupted by high water when nearly completed, and, winter setting in, had to be put off till the ensuing season. At this writing the repairs are resumed, and a few days' work will complete them.

STATISTICS.

The following table is presented as an addition to the commercial statistics of the Kanawha coal-field. This statement was compiled by Mr. N. Fitzhugh, a citizen of this place, and appeared in the Courier newspaper for March 5, 1878. That shipped by rail includes that from the New River mines. The data for rail shipments were furnished by General I. M. St. John, consulting engineer of the Chesapeake and Ohio Railroad; the data for river shipments were furnished by Mr. J. D. Baines, secretary of the Kanawha Board.

Year.	By rail.	By river.	Total per year.
	Bushels.	*Bushels.*	*Bushels.*
1875	5, 792, 925	4, 048, 300	9, 841, 225
1876	6, 609, 650	5, 024, 050	11, 633, 700
1877	7, 758, 800	5, 183, 650	12, 942, 450

SURVEYS, &C.

A survey of the river below Charleston began on September 10, including surveys of the localities on the Kanawha and Elk Rivers where measurements were made for discharge in the flood of January 16, 1877.

The survey began at the foot of Blaine's Island, between Island and Tyler Shoals, and extended into the pool above Red House Shoal and below the mouth of Pocatalico River. Surveys were made of Coal River from its mouth to Lock No. 1 of the Coal River slackwater navigation, and of the Pocatalico River, from its mouth to Lanhanis Dam about 6¾ miles above.

The survey was required chiefly on account of the proposed change of Dam No. 6 from a site at the head of Island Shoal to one below near the head of Tyler Shoal. With this change a new arrangement of the dams below would be desirable.

The survey last season indicates that the arrangement can be changed to the following. (See sheet opposite to page 164 of the Report of the Chief of Engineers for 1876, Part II.)

Dam No. 7, below Peeled Maple Shoal.
Dam No. 8, at head of Tucket's Shoal.
Dam No. 9, below Red House Shoal.
Dam No. 10, below Knob Shoal.

Dam No. 11, above 13-mile Shoal. In this case the miter-sill of Lock No. 11 might probably be 22 inches below the level of low water in the Ohio at the mouth of the Kanawha. If so, and the dam in the Ohio improvement next below the Kanawha should raise the water 5 feet 2 inches at the mouth of the latter stream, Dam No. 12 of the Kanawha series could be dispensed with, saving probably $300,000 in the estimated cost of the Kanawha River improvement.

Further study may show that Dam No. 7 can be located below the mouth of Coal River, and, if so, it is probable that Dam No. 11 may be placed below the foot of 3-mile Bar, in which case heavily-loaded boats could pass into the Ohio at all seasons, whether that river were improved by locks and dams or not.

Further surveys are not necessary. Observations made for the discharge of the Kanawha in the flood of January 16, 1878, reduced by Mr. Scott, give as a result 155,388 cubic feet per second. The measurements were taken between 11 a. m. and 12.45 p. m., the Charleston gauge reading 34½ feet and 34¼ feet at these hours respectively. The river reached its highest point (35.45 feet) at 4.30 p. m. It is, then, probable that the discharge as above was quite the maximum for that rise.

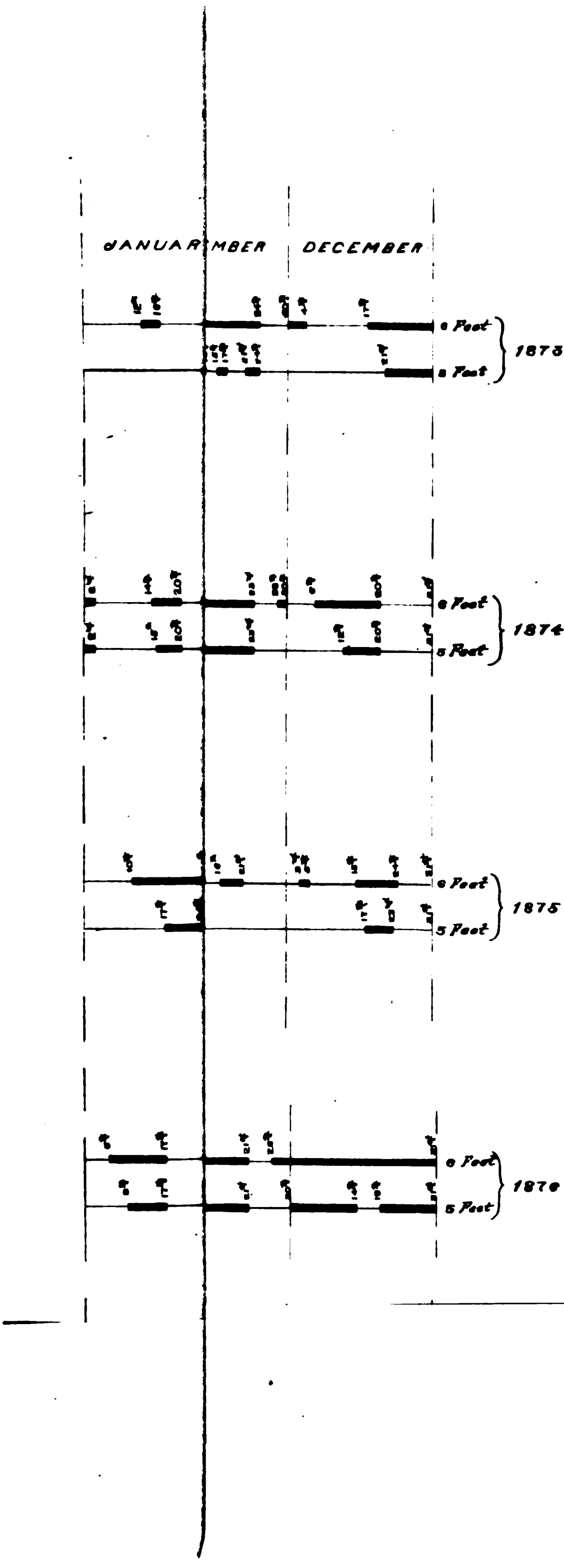
The Elk was gauged on the afternoon of the same day, and the observations give a discharge of 32,959 cubic feet per second.

The discharge of the Kanawha below Elk was then 188,347 cubic feet per second

Table showing the number of days, each year, for five successive years (August 10, 1872, to August 10, 1877), and the average number of days per year for that period, that the Kanawha River has been as high or higher than given gauge-readings. The gauge referred to is the Charleston gauge, which indicates, by its readings, the navigable depth from Charleston to the Ohio River.

Year.	2 feet and upward.	3 feet and upward.	4 feet and upward.	5 feet and upward.	6 feet and upward.	7 feet and upward.	8 feet and upward.	9 feet and upward.	10 feet and upward.	11 feet and upward.	12 feet and upward.	13 feet and upward.	14 feet and upward.	15 feet and upward.	16 feet and upward.	17 feet and upward.	18 feet and upward.	19 feet and upward.	20 feet and upward.	21 feet and upward.	22 feet and upward.	23 feet and upward.	24 feet and upward.
First	330	295	249	194	159	135	107	85	66	61	52	41	35	31	25	19	15	12	10	8	7	6	4
Second	354	295	238	172	123	81	60	46	29	23	20	16	14	11	10	9	8	6	5	4	4	4	3
Third	349	304	275	226	178	135	91	61	43	31	26	20	18	16	15	12	9	9	8	6	6	5	4
Fourth	366	342	285	237	172	119	68	38	23	15	10	6	3	1	.....	.....	.....	.....	.....	.....	.....	.....	.....
Fifth	365	328	264	185	142	96	54	42	35	24	20	18	15	14	13	12	12	10	6	5	5	4	4
Total	1,764	1,564	1,311	1,014	774	566	380	272	196	154	128	101	85	73	63	52	44	37	29	23	22	19	15
Average for 5 years	352.8	312.8	262.2	202.8	154.8	113.2	76	54.4	39.2	30.8	25.6	20.2	17	14.6	12.6	10.4	8.8	7.4	5.8	4.6	4.4	3.8	3

Year.	25 feet and upward.	26 feet and upward.	27 feet and upward.	28 feet and upward.	29 feet and upward.	30 feet and upward.	31 feet and upward.	32 feet and upward.	33 feet and upward.	34 feet and upward.	35 feet and upward.	36 feet and upward.	37 feet and upward.	Remarks.
First	4	3	3	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	August 10, 1872, to August 10, 1873. Lowest water Oct. 22, = 1.50.
Second	3	3	3	2	2	1	1	.....	.....	.....	.....	.....	.....	August 10, 1873, to August 10, 1874. Lowest water Oct. 18, 19, = 1.90.
Third	4	4	4	4	4	4	3	2	2	1	1	1	.....	August 10, 1874, to August 10, 1875. Lowest water Sept. 18, = 1.30.
Fourth	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	August 10, 1875, to August 10, 1876. Lowest water Sept. 13, = 2.34.
Fifth	3	3	3	2	2	2	2	2	2	.....	.....	.....	.....	August 10, 1876, to August 10, 1877. Lowest water Aug. 9, 1877, = 2.11.
Total	14	13	13	9	8	7	6	4	4	1	1	1	.....	
Average for 5 years	2.8	2.6	2.6	1.8	1.5	1.4	1.2	0.8	0.8	0.2	0.2	0.2	.....	


JANUARY
DECEMBER
6 Feet
5 Feet
1873
6 Feet
5 Feet
1874
6 Feet
5 Feet
1875
6 Feet
5 Feet
1876

To illustrate the probable frequency with which the movable dams will be maneuvered on the Kanawha, the adjoined sketch is presented.

In advance of the nicer adjustment which will be derived from experience, it may be stated as a general approximation that on a rising river the lowering of the weir will be completed when the 5-foot stage is reached, and the lowering of the pass will be completed at the 6-foot stage; while, on a falling river, the raising of the wickets of the weir, and of the pass, will be completed at the reverse stages.

Or, referring to the sketch as illustrating the matter, the dams would be entirely open on those dates where the condition of the river is indicated by hair-lines, for both stages, and the dams would be entirely closed where the condition of the river is indicated by broad black lines for both stages. Various partial maneuvers would take place at other times.

The above would be so far modified in the winter months that the dams would be completely down at the low stages, when there would be indications or fear of the formation of ice.

Very respectfully, your obedient servant,

THOMAS TURTLE,
First Lieutenant of Engineers.

Capt. C. B. PHILLIPS,
Corps of Engineers, U. S. A.

F 7.

IMPROVEMENT OF THE CAPE FEAR RIVER, NORTH CAROLINA.

The work of the year has consisted principally in the continued deposition of stone upon the closing work at the New Inlet.

At the date of the last annual report, a contract for the delivery of 45,000 cubic yards of stone upon the work was being executed, about 20,000 yards of the above quantity having then been delivered. This delivery of stone continued, and at the close of the first week in December, 1877, the entire 45,000 yards had been delivered. The contractors were, however, allowed to continue furnishing stone for another month, or until the close of the first week in January, 1878, at which time they had delivered, in all, since January 1, 1877, 49,129 cubic yards of stone, 28,725 yards of which were since July 1, 1877.

Proposals for an additional quantity of stone were invited October 9, 1877, and opened the 15th of the following month. A contract for the delivery of about 12,000 cubic yards of stone was awarded to Mr. W. H. French, of Wilmington, N. C., the contract to be completed by April 30, 1878. He commenced delivering the stone in January, 1878, and on the 6th of the following April had delivered, in all, 11,715 cubic yards. On this date the contract was closed, and work suspended, on account of the near exhaustion of available funds. Total amount of stone deposited upon the dike during the past fiscal year, 40,440 cubic yards.

This stone was distributed quite uniformly over the entire length of the work until it was all brought up gradually to low-water mark, when, from each end of the dike, the work was filled to high-water, in the shape of a ridge, to distances of 850 and 650 feet from Federal and Zeke's Points respectively. The full required width has not yet been given to the structure.

Extensive hydrographic surveys have been made by Mr. Bacon, local engineer, during the year, including New Inlet, outside the closing work, Snow's Marsh Channel, and both the eastern and western channels at the old entrance to the river. Simultaneous tidal observations have also been made from time to time at various points on the river.

The shore-line at Federal Point has remained about the same as at last report except that the general surface has risen. The shore-line of Zeke's Point has extended in a remarkable manner, the low-water line having advanced fully 300 feet on the inlet side. The old worm-eaten

superstructure, between Smith's and Zeke's Islands, has suffered some damage by storms, but no serious consequences are anticipated.

No remarkable changes have taken place in the shore-lines of Bald Head Point and Oak Island, opposite, at the old mouth of the river. The effects of the partial closure of the inlet are beginning to show themselves at the old mouth.

The depth of water on the "rip" of the western channel has increased to about 10½ feet at low-water. The Bald Head Channel has shoaled somewhat during the year, but the distance across the bar has been steadily diminishing. The suction-dredge formerly in use at this bar has remained laid up for want of funds. She is in need of extensive repairs. The necessity of the use of this or some similar dredge upon the Bald Head Bar becomes every day more and more apparent.

The new cut behind the Horseshoe Shoal, known as the "Snow's Marsh" Channel, has remained in the same condition as at last report. The channel is not used, except by light-draught vessels, on account of a shoal at its upper end. It seems useless to attempt to remedy this until after the closure of the inlet shall have been completed or nearly so. The channel at the "Logs" stands well, but additional width should be given it. It is now but 130 feet in width, and should be made at least 250 feet in width.

Mr. Henry Nutt, chairman of the chamber of commerce (Wilmington) committee on the improvement of the Cape Fear River, has continued to exhibit the same marked interest in the work that he has heretofore shown. He has furnished an amount of statistical information in regard to the commerce on this river, all of which accompanies this report.

Mr. Henry Bacon has continued in the immediate supervision of this important and interesting work, and has constantly shown his usual fidelity and efficiency in the discharge of his duties. His detailed report of the operations of this year is appended hereto.

An appropriation of $160,000 for this work was made by act approved June 18, 1878, which fills the estimate of June 30, 1876, for the completion of existing project.

The unexpected settling of the closing work at the inlet will require the deposition of nearly 50,000 cubic yards of stone more than was at first anticipated, which will increase the estimate of 1876 by about $100,000.

Money statement.

July 1, 1877, amount available	$91,788 60	
Amount appropriated by act approved June 18, 1878	160,000 00	
		$251,788 60
July 1, 1878, amount expended during fiscal year		91,230 36
July 1, 1878, amount available		160,558 24
Amount (estimated) required for completion of existing project		100,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880		50,000 00

Cape Fear River.—Bids opened 12.5 p. m., November 15, 1877.

Number.	Name.	Residence.	Quantity furnished monthly.	Time.		Price per cubic yard.
				Commence—	Complete—	
			Cubic yards.			
1	W. H. French	Rocky Point, N. C		Jan. 1, 1878	April 30, 1878	$1 66⅔
2	Bangs & Dolby	New York		Jan. 1, 1878	April 30, 1878	1 89
3	Ingerson & Molthrop	New London, Conn		Jan. 1, 1878	April 30, 1878	2 34

Contractor, W. H. French, at $1.66⅔ per cubic yard.

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Showing the
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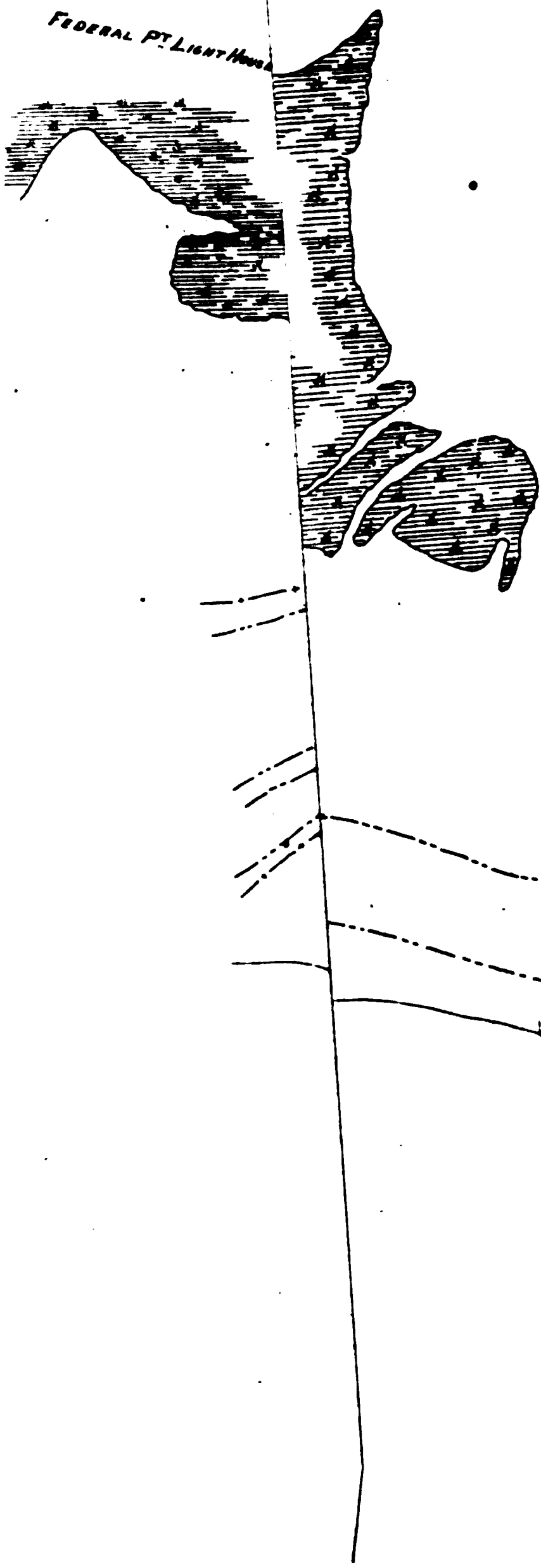
Note:-- 12 feet at Mea
10 " "



REPORT OF MR. HENRY BACON, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Smithville, N. C., June 1, 1878.

CAPTAIN: I have the honor to submit the following report of operations for the improvement of Cape Fear River, North Carolina, during the eleven months ending May 31, 1878.

The work done has been mostly confined to the stone riprap filling on the timber, brush, and stone foundation of the dam extending across the New Inlet from Federal Point to Zeke's Island.

The contract of Messrs. Bangs and Dolby for furnishing and placing the stone, which began in January, 1877, was completed January 7, 1878.

The following are the amounts of stone delivered each month under the contract:

	Cubic yards.
July, 1877	4 844
August, 1877	5,660
September, 1877	4,344
October, 1877	4,670
November, 1877	4,352
December, 1877	3,556
January, 1878	1,299
Total	28,725

The total amount delivered under the contract was 49,129 cubic yards.

Proposals for continuing the work were invited by advertisement of October 9, 1877. The contract was awarded to W. H. French, of Rocky Point, N. C., at $1.66⅔ per cubic yard to the extent of available funds, to be completed on or before April 30, 1878.

The delivery was begun January 11, and completed April 6, 1878, nearly a month before the limit of the contract. The following are the amounts of stone delivered monthly:

	Cubic yards.
January, 1878	2,981
February, 1878	3,572
March, 1878	4,354
April, 1878	808
Total	11,715

This makes the whole amount delivered during the present fiscal year 40,440 cubic yards.

The stone has been placed along the whole length of the dam including the foundation of the old crib-jetty at Federal Point, gradually bringing the work in a ridge to low-water mark, and at filling the ridge to high-water mark, about 850 feet in length from Federal Point, and 650 feet from Zeke's Island, leaving a space to be filled of about 3,150 feet.

No part of the work is completed to the proper width and slopes excepting for a short distance from each shore.

As the work of filling has proceeded the scouring on each side of the dam, occasioned by the overfall of the water, increased so that the depth each side was considerably below the foundation of the dam, but generally sloping from the side of the same. In one place the depth for a short distance on the river side is 30 feet below mean low-water, and 27 feet on the sea side. It is generally from 8 to 12 feet below the original foundation.

At first there were no indications of settlement in the foundation mattresses, but subsequently on all the shoaler portions of the work, embracing nearly all of the middle section (1,588 feet in length) and portions of the shore sections, the water found its way between and under the logs of the mattresses, and gradually settled the foundations so that there is no portion of the dam (excepting short lengths at the shores) where the base is less than 12 feet below mean low-water. No settlement of the foundation has been observed where it was placed in 14 feet depth or more at low-water.

This scouring and subsidence is undoubtedly favorable for ultimate security and permanence, but it involves a larger expenditure of riprap than was expected.

The original estimate (in 1875) was $300,000 for closing the New Inlet. The amount expended, aside from superintendence, is about $207,500. The annexed estimate increases this to about $355,000.

In building the dam to low-water mark in a narrow central ridge, the slopes on a large portion of it fall over the sides of the foundation mattresses to an average depth of 18 to 20 feet below low-water. In filling to high-water mark and to the proper width at the top, these slopes must be filled with stone. This will give security to

the dam and preclude the possibility of further undermining. The scouring seems to have reached its limit in depth. Very little, if any, increase has occurred at any point for several months, and there has been decided shoaling in many places.

It had been suggested that some widening of the mattress foundations, and also that some perpendicular jetties to the dam, would be advisable. One jetty, of about 100 feet length and 40 feet width, was placed without producing any apparent effect. It is evident that the scouring is caused by the overfall of the water and not by parallel currents.

The widening of the foundations by mattresses was not resorted to, as, after the scouring on each side of the dam had occurred, the expense of such work would be nearly or quite as great as the filling the slopes with riprap, while the efficiency would be much more doubtful. The following sectional diagram illustrates the present general condition of the dam, the effect of the scouring by the overfall of the water, and the method of completion proposed.

The forces to be contended with in the closure of the New Inlet are well illustrated by the fact that in the present imperfect state of the dam the water on the river side, toward the last of the ebb-tide, has several times been observed to be 2 feet higher than on the sea side. When the water is completely shut off by the dam, the difference at certain times will probably amount to 3 feet. The flood-currents are apparently as strong as the ebb, but the difference in level cannot be so nearly determined till the dam is completed to high-water. From a comparison of tidal observations made in 1876 and 1877 with those made since the partial completion of the dam, there appears good reason for the opinion expressed in former reports that the range of the tides will be increased rather than diminished in the river at Federal Point and above by the closure of the New Inlet, thus adding a vast force to the scouring power at the mouth by the increase of the volume of water.

The disturbing forces of the New Inlet tides explained in former reports will also be removed. These are especially powerful in the vicinity of the New Inlet and the Horseshoe Channel. The good effect of the partial closure is already apparent. The available depth in the Horseshoe Channel has increased fully one foot since the dam was begun. A reference to the sketch of this vicinity which is annexed hereto will show that good results should be expected. The main flood after the full closure will no longer be met near the Horseshoe Channel by the inlet flood, nor the main ebb-currents be diverted and disturbed by those of the inlet.

The primal fact which lies at the foundation of the great deleterious influence of the New Inlet as well as of the difficulty of closure, is that the average time of the tides at the natural entrance and on the sea side of the New Inlet dam, when finished, will be nearly simultaneous, while the same on the river side of the dam will average fully an hour behind. There is, therefore, or will be during more than half the time of each tide, an alternating average difference of at least 1 foot, in level, which is varied at different periods of the tide and with different tides and winds.

As the volume of the New Inlet tide, though large in itself, is small compared with the overwhelming tides of the entrance, there has been some approximation to the effect which may be conceived to be produced by the interposition and sudden removal of the complete dam, at the times of these differences of level.

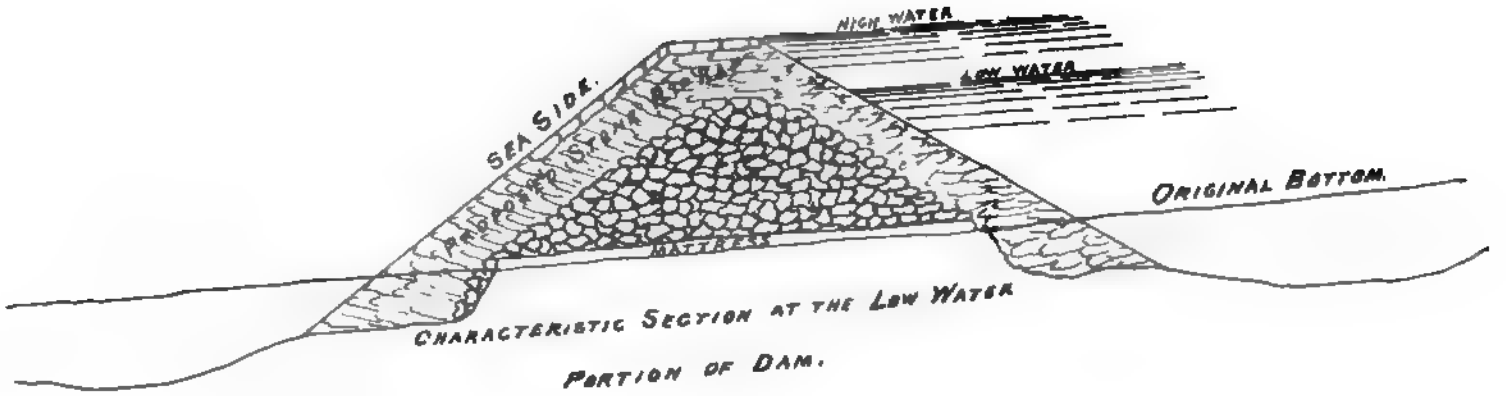
The effect of the partial closure of the New Inlet is already apparent at the natural entrance. It is believed that the "Rip" of the western channel was never so long in so good a condition. It has been reliable for fully 9 feet depth at mean low-water since October 1, 1877. At the present time the shoalest soundings are 10½ feet, excepting for a distance not exceeding 60 feet on soft sand.

The effect at the Bald Head Channel is less apparent but not less real. Since the coast survey of 1872, the distance across the bar, from 12 to 12 feet depth at mean low-water, has diminished from 2,400 to 1,200 feet, and the deep water is pushing in a direct line across the bar. It is very unfortunate that funds have not been available to assist in the process. It is probable that this process and its incompletion accounts for the slight shoaling on the bar which has occurred during the year. The shoalest soundings are now 9 feet at mean low-water for very short distances (in two places) on shifting sands.

No great permanent changes have occurred in the shore-lines of Federal Point. During the prevalence of strong southwest winds, and a course of high tides in August, 1877, a tendency to flank the dam at Federal Point was experienced. This was promptly checked by stone filling, and the dam was made much more secure thereby. A line of sheet-piling was also driven from the end of the dam to the high mound at the quarters. The sand has formed a ridge over it above the highest tides. The general surface of the land has risen.

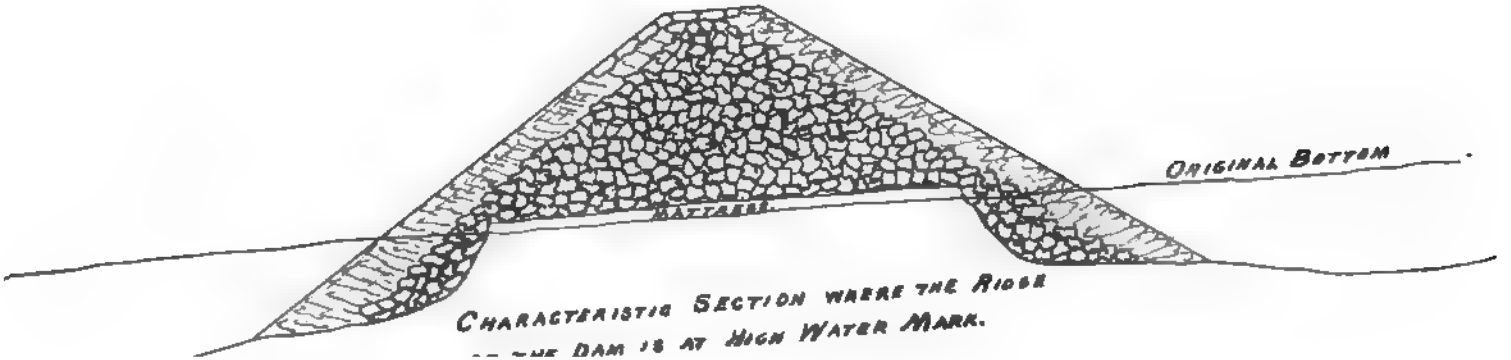
Some abrasions have occurred, but they have been followed by accretion, and there has been a general advance of the crest and low-water lines.

Considerable changes have occurred in the shore-lines of Zeke's Island, especially on the easterly side and near the dam. The low-water line has advanced about 300



CHARACTERISTIC SECTION AT THE LOW WATER PORTION OF DAM.

SCALE. $20^{FT} = 1^{IN}$



CHARACTERISTIC SECTION WHERE THE RIDGE OF THE DAM IS AT HIGH WATER MARK.

feet for a distance of more than a quarter of a mile. The crest line has made a less advance.

There has been a general growth of the island excepting near its connection with Smith's Island. In this vicinity there has always been alternate accretion and abrasion on the sea side. The old superstructure of the connecting works was thoroughly worm-eaten, so that little force beyond the buoyancy of the water was required to move it. About 150 feet in length was washed out by the storm of September 17, 1876, as per last report.

During the past two months a new breach has been made in it of about 300 feet in length, a little northerly of the other, so that the water passes freely at half tides. As the foundation stone and timbers are intact, there is no immediate danger of a thorough breach. It is intended to repair these breaches as soon as funds are available.

The ultimate strength of the work will be increased by the washing of a large amount of sand from the sea side, and filling the deep water on the bay or river side.

The long narrow sand-beach of Smith's Island which separates the sea from the bay has improved in condition during the year, although the "swashes" across the beach, some 3 and 4 miles from the head of the island, remain open.

At the beginning of the year the spring tides washed over several miles of this beach. During the year it has risen above the highest tides excepting at the swashes. These have now an aggregate width of about 2,950 feet at high-water. This embraces the middle ground between the first two "swashes," which is bare at about half tide, and about 1,400 feet in length. The southerly swash, originally about 800 feet in width at high-water, has diminished to less than 200 feet.

The process of shoaling in the rear of the "swashes" has continued throughout the year. There is but little doubt of their ultimate closure by natural causes and of the growth of a large area of marsh or grass lands, thus forming the best defense against future breaches and repeating former experience, and especially of the great breaches of 1857.

By reference to the surveys of Lieutenant Glynn of 1839, it appears that the long narrow sand-beach was bordered with but very little marsh. Comparison with subsequent surveys shows its growth in the rear of the several breaches, and especially of the great breaches of 1857. It is to be noticed that these breaches cause a more rapid recession of the general line of the beach.

The present breaches are so remote from the river and channels and the New Inlet, and so little influenced by its closure, that no immediate danger can be apprehended from them. Therefore no expenditure is recommended for their closure during the coming year unless there be more unfavorable developments.

No great changes in the shore-line of Bald Head Point and the opposite point of Oak Island have occurred during the year. The southwestern shore of Bald Head Point has receded and there has been some advance northward and eastward. The width from point to point remains about the same.

The new cut behind the Horseshoe Channel near Snow's Marsh has remained in the same condition during the year. The shoaling at the upper end destroys its utility for more than 8 feet draught at low-water. A reference to the annexed sketch will show the remedy proposed.

It is apparent from the general shape and condition of the river and channel, as well as from observations, that the prevailing tidal currents both of the ebb and flood, and especially the ebb, cross the upper or shoaled portion of the cut obliquely, and will do so after the complete closure of the New Inlet. This is the cause of the shoaling, the bottom being sandy.

It is not believed to be practicable at any reasonable expense to divert the main currents through the cut; but by giving the upper end of it a new direction above Snow's Marsh parallel with the prevailing currents, extending it to the 12-foot pocket, which is very nearly connected with the main channel of 12 feet depth at low-water (as may easily be done by a very small amount of dredging), a good and reliable subsidiary channel may be obtained of 12 feet depth at low-water, much more reliable and permanent than the Horseshoe Channel, as that will always be more subject to cross, changeable, and opposing currents, which are the source of its changes and deterioration.

The channel thus obtained will more than justify all the expense thus far incurred by dredging it, and the comparatively small expense proposed to make it available.

The new dredged channel at the "Logs," near Campbell's Island, retains its depth of 12 feet at low-water. It is only 130 feet in width, and it should be widened to make it more serviceable.

The exhaustive hydrographic survey of the river between New Inlet, Snow's Marsh, the deep water above Federal Point and below Price's Creek light house, has been completed and the map projected on a scale of 200 feet to an inch.

A like survey of the New Inlet extending over the whole basin and to deep water over the shoals has also been made, and the maps projected on a scale of 400 feet to an inch.

feet for a distance of more than a quarter of a mile. The crest line has made a less advance.

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The new cut behind the Horseshoe Channel near Snow's Marsh has remained in the same condition during the year. The shoaling at the upper end destroys its utility for more than 8 feet draught at low-water. A reference to the annexed sketch will show the remedy proposed.

It is apparent from the general shape and condition of the river and channel, as well as from observations, that the prevailing tidal currents both of the ebb and flood, and especially the ebb, cross the upper or shoaled portion of the cut obliquely, and will do so after the complete closure of the New Inlet. This is the cause of the shoaling, the bottom being sandy.

It is not believed to be practicable at any reasonable expense to divert the main currents through the cut, but by giving the upper end of it a new direction above Snow's Marsh parallel with the prevailing currents, extending it to the 12-foot pocket, which is very nearly connected with the main channel of 12 feet depth at low-water (as may easily be done by a very small amount of dredging), a good and reliable subsidiary channel may be obtained of 12 feet depth at low-water, much more reliable and permanent than the Horseshoe Channel, as that will always be more subject to cross, changeable, and opposing currents, which are the source of its changes and deterioration.

The channel thus obtained will more than justify all the expense thus far incurred by dredging it, and the comparatively small expense proposed to make it available.

The new dredged channel at the "Logs," near Campbell's Island, retains its depth of 12 feet at low-water. It is only 130 feet in width, and it should be widened to make it more serviceable.

The exhaustive hydrographic survey of the river between New Inlet, Snow's Marsh, the deep water above Federal Point and below Price's Creek light house, has been completed and the map projected on a scale of 200 feet to an inch.

A like survey of the New Inlet extending over the whole basin and to deep water over the shoals has also been made, and the maps projected on a scale of 400 feet to an inch.

A thorough survey of the Bald Head and western channels of the natural entrance has been made, and projected on a scale of $\frac{1}{5000}$.

The triangulation in preparation for a complete hydrographic survey of the river connecting the above surveys has been made.

Reconnaissances and examinations have been made and reported from time to time of Federal Point, Zeke's and Smith's Islands, Bald Head Point, &c.

The tug James T. Easton, and the crew of the same, have been very useful in these surveys, and very little extra labor has been employed on them. The tug was laid up under the care of a watchman and the crew discharged December 31, 1877. Some repairs will be required to put her in running order.

The suction-dredge Woodbury has been laid up under the care of a watchman during the year. Her hull and machinery have necessarily suffered some from decay and rust. Her boiler is known to be worthless. The machinery and pumping apparatus are in reasonably good condition.

Simultaneous tidal observations have been taken, especially at Smithville, Federal Point, and Wilmington. They have not been taken with a view to determine the absolute average *range* of the tides so much as their *relative* movements and ranges at the several places.

Some of the comparative results of these observations are shown below. These tidal observations will, on comparison with future observations which may be made at the same places after closing the New Inlet, show the effect of that work on the tidal movements.

From 184 simultaneous observations, each of high and adjacent low-water in 1876 and 1877, and 71 similar observations of the same from February 11, 1878, to May 30, 1878, since the partial closure of the New Inlet, the following results appear:

One hundred and eighty-four observations in 1876 and 1877.

	Smithville.	Federal Point.
	Feet.	*Feet.*
Average high-water	4.88	4.50
Average low-water	0.39	0.62
Average range	4.49	3.88
Per centage of Smithville range	.....	86 per ct.

Seventy-one observations in 1878.

	Smithville.	Federal Point.	
		River side.	Sea side.
	Feet.	*Feet.*	*Feet.*
Average high-water	4.95	4.31	4.32
Average low-water	0.98	1.00	0.61
Average range	3.97	3.31	3.71
Percentage of Smithville range	.....	83½ per ct.	93½ per ct.

Comparative results of twenty-eight simultaneous observations of high-water and adjacent low-water, from April 22, 1878, to May 30, 1878.

	Smithville.	Federal Point.		Wilmington.
		River side.	Sea side.	
	Feet.	*Feet.*	*Feet.*	*Feet.*
Average high-water	4.91	4.29	4.30	4.42
Average low-water	1.07	1.07	0.74	1.75
Average range	3.84	3.22	3.56	2.67
Approximate percentage of Smithville range	.....	0.84	0.93	0.70
Approximate percentage of Federal Point, river side, range	.....	.....	.....	0.83

The tides observed in 1876 and 1877 give about the average range at Smithville. Those observed in 1878 give less than the average, because more of the larger tides were omitted.

The present condition of the dam does not allow the full natural ebb on the river side by reason of the influx of the inlet flood, nor the full flood on account of the outflow with the inlet ebb. If the dam had been complete during the above observations of 1878, it seems certain that the average range on the river side would have been at least 88 per cent. of the average range at Smithville, and the percentage would have been still further increased if a proper portion of the larger tides had been observed so as to bring the average to the *mean* range.

PROBABLE OPERATIONS FOR THE COMING FISCAL YEAR.

The operations proposed being dependent on the amounts to be appropriated by Congress, are mentioned below in the order of their importance.

It is of the utmost importance for the security and preservation of the work already done that the New Inlet Dam should be finished to high-water mark as rapidly as practicable. This requires a larger amount of work than had been anticipated, for reasons before stated.

The price of stone riprap has, by competition and skill in working, been largely reduced since the former estimates. It can be obtained in open market at the estimated price.

It is of equal importance that the old works connecting Zeke's and Smith's Islands should be thoroughly repaired.

The importance of assisting the concentration of natural forces, which are being so largely increased by the closure of the New Inlet, and consequent increase of the volume and force of the tidal currents at the mouth of the river, requires and justifies all reasonable expenditure therefor. It is recommended that this should be done by the use of a suction-dredge to complete the Bald Head Channel across the bar. This method of dredging is peculiarly well adapted to the work and to the material on this bar. It is believed that the dredge Woodbury can be thoroughly repaired, with a large new boiler and in hull, house, machinery, &c., so as to make her powerful and effective for the work, for $14,000.

The completion of the new cut above Snow's Marsh, before described, is recommended. So also the widening of the dredged channel near Campbell's Island. The dredging in both these places is more expensive than ordinary excavation, as there is some compact sand at the proposed channel above Snow's Marsh, and some stumps and logs may be expected at the channel near Campbell's Island.

The following estimates are presented for the coming fiscal year. It is hoped that the full amount may be granted. The growing importance of Wilmington, the commercial metropolis of the State, demands persistence in the improvement of the river and entrance.

74,000 cubic yards for New Inlet Dam, at $1.65½	$123,333 33
6,000 cubic yards large stone, for top on sea-face of dam, at $4	24,000 00
Repairs of old works at Zeke's and Smith's Islands	10,000 00
Repairs of suction-dredge Woodbury	14,000 00
Operation of suction-dredge, 8 months	8,000 00
80,000 cubic yards dredging at Snow's Marsh Channel, at 25 cents	20,000 00
60,000 cubic yards dredging at Campbell's Island Channel, at 30 cents	18,000 00
Superintendence and surveys	15,000 00
Contingencies (about 10 per cent.)	23,666 67
Total	256,000 00

Respectfully submitted.

HENRY BACON,
Assistant Engineer.

Capt. C. B. PHILLIPS,
Corps of Engineers, United States Army.

ANNUAL EXPORT TABLE.

Statement of the principal articles of produce and manufacture exported from the port of Wilmington, N. C., to points out of the State, for the year ending December 31, 1877, and compared with the years 1876, 1875, and 1874; also the receipts of a few articles for the same period, with a note of the shipping for 1877.

[Compiled by JOHN L. CANTWELL, *Secretary of the Wilmington Produce Exchange.*]

DOMESTIC.

	Sundries.												Barrels.						
	Lumber.	Shingles.	Railroad-ties.	Juniper bolts.	Ores and metals, pounds.	Coal, tons.	Soapstone, tons.	Barytes, tons.	Peanuts, bushels.	Leather, rolls.	Hides, bundles.	Hoop-iron.	Gold ore.	Spirits turpentine.	Rosin.	Tar.	Crude turpentine.	Pitch.	Rosin oil.	Kerosene oil.
Baltimore	2,449,316	824,172	.....	11,130	84,751	....	....	....	49,228	431	40	....	....	6,575	23,093	10,423	730	2,282	68	....
Bath	1,529,189	.....	.....	.....	.....	....	....	....	.....	.....	.....	....	....	.....	5	2	.....	5	....	....
Boston	6,121	.....	.....	.....	.....	....	....	835	.....	.....	.....	....	....	923	10,604	9,901	525	1,378	....	....
Bucksport	333,627	.....	.....	.....	.....	....	....	....	.....	.....	.....	....	....	.....	.....	15	.....	15	....	....
Carolina Central Railway	.....	.....	.....	.....	.....	....	....	....	650	.....	.....	....	....	80	.....	6	.....	62	....	....
Kennebunkport	1,215,930	.....	.....	.....	.....	....	....	....	.....	.....	.....	....	....	.....	.....	.....	.....	20	....	....
Navassa Guano Company	.....	.....	.....	.....	.....	....	....	....	.....	.....	.....	....	....	.....	.....	.....	.....	.....	....	....
New Bedford	.....	.....	.....	.....	.....	....	....	....	.....	.....	.....	....	....	.....	250	900	.....	.....	....	....
Newburyport	225,956	.....	.....	.....	.....	....	....	....	.....	.....	.....	....	....	.....	.....	.....	.....	.....	....	....
New York	580,048	1,277,700	.....	.....	194,429	....	186	....	5,345	87	106	....	3	13,193	47,781	9,298	3,465	315	42	....
Philadelphia	207,176	2,399,584	.....	43,489	1,781,840	....	....	....	.....	.....	.....	....	....	.....	3,423	1,154	.....	200	....	....
Portsmouth, N. H	350,656	.....	.....	.....	.....	....	....	....	.....	.....	.....	....	....	.....	.....	.....	.....	.....	....	....
Richmond	219,640	.....	.....	.....	.....	....	....	....	.....	.....	.....	....	....	.....	.....	.....	.....	.....	....	....
Rockland	123,679	.....	.....	.....	.....	....	....	....	.....	.....	.....	....	....	.....	.....	.....	.....	.....	....	....
Rockport	188,049	.....	.....	.....	.....	....	....	....	.....	.....	.....	....	....	.....	.....	.....	.....	.....	....	....
Sundry	.....	.....	.....	.....	.....	....	....	....	.....	.....	.....	....	....	973	519	1,238	275	.....	....	....
Thomaston	226,568	.....	.....	.....	.....	....	....	....	.....	.....	.....	....	....	.....	.....	.....	.....	.....	....	....
Waldoboro'	392,583	.....	.....	.....	.....	....	....	....	.....	.....	.....	....	....	2	.....	.....	.....	5	....	....
Wilmington Cotton Mills	.....	.....	.....	.....	.....	....	....	....	.....	.....	.....	....	....	.....	.....	.....	.....	.....	....	....
Wil., Col. & Aug. Railroad	73,485	.....	.....	.....	285,595	50	647	....	13,377	7	.....	357	....	1,410	165	1,482	50	334	75	56
Wilmington & Weldon Railroad	10,020	.....	.....	.....	1,215,823	3	....	....	1,970	802	.....	....	....	71	562	523	3	130	5	....
Salem	.....	138,175	.....	.....	.....	....	....	....	.....	.....	.....	....	....	.....	.....	.....	.....	.....	....	....
Total, 1877	8,132,043	12,639,631	.....	54,619	3,562,438	53	833	835	70,570	1,327	146	357	3	23,227	86,402	34,943	5,048	4,746	190	56
Total, 1876	7,575,772	2,963,225	.....	55,532	2,650,860	....	....	687	44,405	341	977	....	....	29,433	110,970	34,106	3,900	5,762	117	....
Total, 1875	3,916,066	3,330,200	.....	76,889	664	....	....	....	41,138	39	270	....	....	22,239	222,930	30,540	7,955	4,994	156	....
Total, 1874	9,998,295	5,432,408	.....	110,476	8,741	....	....	....	33,562	683	3,570	....	....	42,708	307,758	47,820	14,945	7,316	133	....

Amsterdam																					
Antwerp															6,000	25,500					
Arroyo	171,293	250,200															10		3		
Barcelona																1,770					
Belfast															450	3,932					
Bremen																					
Bristol															6,527	19,074					
Cardenas	160,334														4		75				
Cardiff																1,700					
Cette																3,157					
Cienfuegos	160,234																				
Cape Haytien	362,452	210,700																			
Channel, for orders															20,453	6,768					
Demerara	801,088															10	150		150		
Fajardo	294,656	227,200																			
Genoa																4,750					
Glasgow															5,905	41,785	4,705				
Guyenella	133,818	41,000																			
Greenock																	2,103				
Havre																					
Humacao	185,022														3		20				
Havana	834,255		3,401												37	400	200		25		
Hamburg															6,094	110,463					
Hull															3,516	10,391	6,885				
Halifax																142	402		300	5	
Hayti	70,748	40,000																			
Saint Marc	116,406	150,000																			
Petit Goave	173,000	40,000																			
Gonaives	465,402	127,200																			
Anse de Hinault	82,958	100,000													3	2	2		2		
Aux Cayes	352,666	250,800														5	5				
Jacmel	250,627	150,000																			
Jeremie	273,484	372,000																			
Laguayra	455,558															746					
Liverpool															3,377	29,145	18,403	1,087			
London															24,225	61,780					
Marseilles																6,367					
Moule	63,185	250,117																			
Mayaguez	423,287																				
Navassa Guano Company																					
Nassau	9,345	158,317															2				
Naples																2,200					
Newcastle															200	5,137	2,000				
Point-a-Pitre	390,657	71,225												30							
Ponce	370,073	163,606																			
Port au Prince	1,340,864	261,150																			
Rotterdam															1,806	50,500					
Saba	86,357	32,500													2	3	10		5		
Stettin																41,428					

Statement of the principal articles of produce and manufacture exported from the port of Wilmington, N. C. &c.—Continued.

FOREIGN—Continued.

Destination.	Sundries.												Barrels.							
	Lumber.	Shingles.	Railroad-ties.	Juniper bolts.	Ores and metals, pounds.	Coal, tons.	Soapstone, tons.	Barytes, tons.	Peanuts, bushels.	Leather, rolls.	Hides, bundles.	Hoop-iron.	Gold ore.	Spirits turpentine.	Rosin.	Tar.	Crude turpentine.	Pitch.	Rosin oil.	Kerosene oil.
Saint Martin's and Nevis	84, 844	159, 175	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Saint Pierre	119, 000	53, 065	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3	.....	.....	.....	.....	.....	.....
Saint George	372, 143	254, 400	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3	1	.....	2	.....	.....
Saint John's, P. R	155, 632	50, 000	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	25	.....	.....	.....	.....
Saint John, N. B	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	50	.....	50	.....	.....
Saint Stephen	131, 630	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Trieste	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	24, 136	.....	.....	.....	.....	.....
Total, 1877	8, 892, 018	3, 412, 655	3, 401	.....	.....	.....	.....	.....	.....	.....	.....	30	....	78, 605	451, 294	38, 048	1, 087	537	5	....
Total, 1876	8, 122, 860	1, 926, 555	3, 816	.....	.....	.....	.....	.....	.....	.....	.....	.....	....	62, 159	379, 585	27, 785	1, 535	316	100	....
Total, 1875	5, 904, 541	1, 859, 000	12, 113	.....	.....	.....	.....	.....	.....	.....	.....	.....	....	85, 181	300, 400	16, 619	339	182	.....	....
Total, 1874	4, 231, 030	3, 057, 805	22, 898	.....	.....	.....	.....	.....	.....	.....	.....	.....	....	83, 129	248, 424	20, 799	650	167	.....	....

GRAND TOTAL.

Total domestic and foreign, 1877	17, 024, 061	16, 052, 286	3, 401	54, 619	3, 562, 438	53	833	835	70, 570	1, 327	146	387	3	101, 832	537, 696	69, 991	6, 135	5, 283	195	56
Total domestic and foreign, 1876	15, 698, 632	4, 889, 780	3, 816	55, 532	2, 650, 860	....	....	687	44, 455	341	977	....	....	91, 592	490, 555	61, 891	5, 435	6, 078	217	....
Total domestic and foreign, 1875	9, 820, 007	5, 189, 200	12, 113	76, 889	664	....	....	....	41, 138	39	270	....	....	107, 420	523, 330	47, 159	8, 298	1, 176	156	....
Total domestic and foreign, 1874	14, 229, 325	8, 520, 213	22, 898	116, 476	8, 741	....	....	....	33, 562	683	3, 570	....	....	125, 837	556, 182	.....	.....	7, 433	153	....

RECEIPTS.

Total, 1877	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....	105, 066	534, 246	66, 898	143, 455	.....	.....	....
Total, 1876	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....	94, 273	498, 765	64, 441	1 9, 617	.....	.....	....
Total, 1875	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....	102, 014	552, 113	47, 159	82, 974	.....	.....	....
Total, 1874	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....	128, 516	641, 140	68, 619	15, 575	.....	.....	....

DOMESTIC—Continued.

Destination.	Barrels.														Hhds.		Cases.		Bales.								
	Light wood.	Glue.	Eggs.	Vegetables.	Liquors, domestic.	Wines, domestic.	Bottles.	Rice.	Hominy.	Sugar.	Fish.	Lime.	Molasses.	Flour.	Sugar.	Molasses.	Spirits turpentine.	Tar.	Bagging.	Waste.	Cotton.	Cotton goods.	Yarn.	Wool.	Rags.	Hay.	Bags.
Baltimore	....	....	3	139	34	5	3	3	....	....	48	.....	.....	108	....	100	46	1,300	....	73	7,839	1,318	4,587	93	185	....	94
Bath	....	....	....	.....	....	....	....	....	....	....	....	.....	.....	.....	....	.....	....	.....	....	....	.....	.....	.....	....	....	....	....
Boston	....	....	....	.....	....	....	....	....	....	....	....	.....	.....	.....	....	.....	....	43	....	....	31	.....	.....	....	....	....	....
Bucksport	....	....	....	.....	....	....	....	....	....	....	....	.....	.....	.....	....	.....	....	.....	....	....	.....	.....	.....	....	....	....	....
Carolina Central Railway	....	....	....	1	2	3	....	9	1	5	1	.....	46	10	....	38	....	.....	....	....	96	9	.....	....	....	....	....
Kennebunkport	....	....	....	.....	....	....	....	....	....	....	....	.....	.....	.....	....	.....	....	.....	....	....	.....	.....	.....	....	....	....	....
Navassa Guano Company	....	....	....	.....	....	....	....	....	....	....	....	.....	.....	.....	....	.....	....	.....	....	....	.....	.....	.....	....	....	....	....
New Bedford	....	....	....	.....	....	....	....	....	....	....	....	.....	.....	.....	....	.....	....	.....	....	....	.....	.....	.....	....	....	....	....
Newburyport	....	....	....	.....	....	....	....	....	....	....	....	.....	.....	.....	....	.....	....	.....	....	....	.....	.....	.....	....	....	....	....
New York	282	3	120	34	13	4	166	....	....	50	108	.....	.....	379	697	25	1	140	....	37	48,849	974	590	32	39	....	18
Philadelphia	....	....	....	.....	....	....	....	....	....	....	....	.....	.....	.....	....	.....	....	.....	....	....	18	.....	.....	....	....	....	....
Portsmouth, N. H	....	....	....	.....	....	....	....	....	....	....	....	.....	.....	.....	....	.....	....	.....	....	....	.....	.....	.....	....	....	....	....
Richmond	....	....	....	.....	....	....	....	....	....	....	....	.....	.....	.....	....	.....	....	.....	....	....	.....	.....	.....	....	....	....	....
Rockland	....	....	....	.....	....	....	....	....	....	....	....	.....	.....	.....	....	.....	....	.....	....	....	.....	.....	.....	....	....	....	....
Rockport	....	....	....	.....	....	....	....	....	....	....	....	.....	.....	.....	....	.....	....	.....	....	....	.....	.....	.....	....	....	....	....
Sundry	....	....	....	.....	....	....	....	....	....	....	....	.....	.....	.....	....	.....	....	.....	....	....	319	.....	.....	....	....	....	....
Thomaston	....	....	....	.....	....	....	....	....	....	....	....	.....	.....	.....	....	.....	....	.....	....	....	.....	.....	.....	....	....	....	....
Waldoboro'	....	....	....	.....	....	....	....	....	....	....	....	.....	.....	.....	....	.....	....	.....	....	....	.....	.....	.....	....	....	....	....
Wilmington Cotton Mills	....	....	....	.....	....	....	....	....	....	....	....	.....	.....	.....	....	.....	....	.....	....	100	.....	300	.....	....	....	....	....
Wil., Col. & Aug. Railroad	29	94	....	543	684	14	....	433	526	557	404	1,211	1,617	4,086	....	346	....	489	793	....	2,490	257	75	....	....	440	8
Wilmington & Weldon Railroad	110	26	....	790	145	17	....	29	50	72	294	12	751	65	....	626	2	.....	43	331	1,084	630	2	19	....	300	11
Salem	....	....	....	.....	....	....	....	....	....	....	....	.....	.....	.....	....	.....	....	.....	....	....	.....	.....	.....	....	....	....	....
Total, 1877	421	123	123	1,507	878	43	169	474	577	684	855	1,223	2,414	4,648	697	1,135	49	1,792	836	541	63,598	3,488	5,254	144	234	740	131
Total, 1876	....	....	155	884	163	17	47	47	21	36	364	18	132	4	....	328	453	1,515	36	157	69,682	3,511	4,076	179	447	....	95
Total, 1875	....	....	65	63	49	....	....	157	....	....	....	.....	.....	15	....	172	225	770	....	....	53,123	1,984	1,260	98	246	....	....
Total, 1874	....	....	175	.....	145	....	....	298	....	....	....	.....	.....	261	....	568	376	716	....	....	52,635	2,375	1,095	138	399	....	....

Statement of the principal articles of produce and manufacture exported from the port of Wilmington, N.C., &c.—Continued.

FOREIGN—Continued.

Destination.	Barrels.														Hhds.		Cases.		Bales.								
	Light wood.	Glue.	Eggs.	Vegetables.	Liquors, domestic.	Wines, domestic.	Bottles.	Rice.	Hominy.	Sugar.	Fish.	Lime.	Molasses.	Flour.	Sugar.	Molasses.	Spirits turpentine.	Tar.	Bagging.	Waste.	Cotton.	Cotton goods.	Yarn.	Wool.	Rags.	Hay.	Bags.
Amsterdam																					9,838						
Antwerp																					2,411						
Arroyo																											
Barcelona																											
Belfast																											
Bremen																					2,870						
Bristol																											
Cardenas																											
Cardiff																											
Cette																											
Cienfuegos																											
Cape Haytien																											
Channel, for orders																					800						
Demerara																											
Fajardo								1																			
Genoa																											
Glasgow																											
Guyenella																											
Greenock																											
Havre																					3,280						
Humacao																											
Havana																	200										
Hamburg																					1,066						
Hull																											
Halifax																		10									
Hayti																											
Saint Marc																											
Petit Goave																											
Gonaives																											
Anse de Hinault																											
Aux Cayes																											
Jacknel																											
Jeremie																											

Laguayra						1															27, 905						
Liverpool																											
London																											
Marseilles																											
Moule																											
Mayaguez																											
Navassa Guano Company																											
Nassau																2											
Naples																											
Newcastle																											
Point a Petre																											
Ponce																											
Port au Prince																											
Rotterdam																					1, 965						
Saba																											
Stettin																											
Saint Martin's and Nevis																											
Saint Pierre																											
Saint George																											
Saint John's, P. R																											
Saint John, N. B																											
Saint Stephen																											
Trieste																											
Total, 1877						1		1								202	10				50, 135						
Total, 1876				7										60		270					33, 202	11					
Total, 1875																					18, 140						
Total, 1874																					11, 927	3	26				

GRAND TOTAL.

Total domestic and foreign, 1877	421	123	123	1, 507	878	41	166	475	577	684	855	1, 223	2, 414	4, 648	697	1, 135	251	1, 982	836	541	113, 733	3, 488	5, 254	144	234	740	131
Total domestic and foreign, 1876	....	....	155	891	173	17	47	47	21	36	36	18	132	64	....	328	453	1, 515	36	157	102, 884	3, 522	4, 076	179	447	....	95
Total domestic and foreign, 1875	....	....	65	63	49	....	....	157	....	....	....	....	....	15	....	172	22	770	....	....	71, 262	1, 984	1, 260	98	246	....	....
Total domestic and foreign, 1874	....	....	175	....	145	....	....	298	....	....	....	....	....	261	....	568	376	717	....	....	63, 562	2, 378	1, 121	138	399	....	....

RECEIPTS.

Total, 1877																					117 663						
Total, 1876																					111, 434						
Total, 1875																					88, 839						
Total, 1874																					67, 150						

Statement of the principal articles of produce and manufacture exported from the port of Wilmington, N. C. &c.—Continued.

DOMESTIC—Continued.

Destination.	Packages.																Bags.						
	Paper-stock.	Roots and herbs.	Tobacco.	Beeswax.	Furs.	Shooks.	Rope.	Fruit.	Dried fruit.	Empty casks, barrels, &c.	Lard.	Bones.	Merchandise.	Feathers.	Bacon.	Paper.	Cotton-ties.	Coffee.	Guano.	Salt.	Corn.	Rough rice.	Meal.	Asbestos.
Baltimore	90	327	7	47	5	.....	50	97	11,359	14,607	....	44	942	17	.....	295	.....	4	276	.....	74	....	.....	93
Bath	....	.....	....	....	....	.....	....	....	.....	.....	....	....	.....	....	.....	.....	.....	....	.....	.....	.....	....	.....	....
Boston	....	.....	....	....	....	.....	....	....	.....	.....	....	....	7	....	.....	.....	.....	....	.....	.....	.....	....	.....	....
Bucksport	....	.....	....	....	....	.....	....	....	.....	.....	....	....	.....	....	.....	.....	.....	....	.....	.....	.....	....	.....	....
Carolina Central Railway	....	.....	....	....	....	.....	....	....	7	.....	4	....	644,175	....	.....	.....	20	14	26,177	4,527	.....	....	.....	....
Kennebunkport	....	.....	....	....	....	.....	....	....	.....	.....	....	....	.....	....	.....	.....	.....	....	.....	.....	.....	....	.....	....
Navassa Guano Company	....	.....	....	....	....	.....	....	....	.....	.....	....	....	.....	....	.....	.....	.....	....	86,525	.....	.....	....	.....	....
New Bedford	....	.....	....	....	....	.....	....	....	.....	.....	....	....	.....	....	.....	.....	.....	....	.....	.....	.....	....	.....	....
Newburyport	....	.....	....	....	....	.....	....	....	.....	.....	....	....	.....	....	.....	.....	.....	....	.....	.....	.....	....	.....	....
New York	21	773	....	145	27	8,009	4	10	1,778	2,714	....	....	2,440	18	1	200	.....	....	8	.....	.....	....	4	408
Philadelphia	....	.....	....	....	....	.....	....	....	.....	.....	....	....	.....	....	.....	.....	.....	....	.....	.....	.....	....	.....	....
Portsmouth, N. H	....	.....	....	....	....	.....	....	....	.....	.....	....	....	.....	....	.....	.....	.....	....	.....	.....	.....	....	.....	....
Richmond	....	.....	....	....	....	.....	....	....	.....	.....	....	....	.....	....	.....	.....	.....	....	.....	.....	.....	....	.....	....
Rockland	....	.....	....	....	....	.....	....	....	.....	.....	....	....	.....	....	.....	.....	.....	....	.....	.....	.....	....	.....	....
Rockport	....	.....	....	....	....	.....	....	....	.....	.....	....	....	.....	....	.....	.....	.....	....	.....	.....	.....	....	.....	....
Sundry	....	.....	....	....	....	.....	....	....	.....	.....	....	....	.....	....	.....	.....	.....	....	.....	3,900	.....	....	.....	....
Thomaston	....	.....	....	....	....	.....	....	....	.....	.....	....	....	.....	....	.....	.....	.....	....	.....	.....	.....	....	.....	....
Waldoboro'	....	.....	....	....	....	.....	....	....	.....	.....	....	....	.....	....	.....	.....	.....	....	.....	.....	.....	....	.....	....
Wilmington Cotton Mills	....	.....	....	....	....	.....	....	....	.....	.....	....	....	.....	....	.....	.....	.....	....	.....	.....	.....	....	.....	....
Wil., Col. & Aug. Railroad	10	1	511	....	....	.....	26	119	50	7,817	388	....	11,060	1	2,079	81	3,236	771	28,417	26,097	31,752	805	11,002	....
Wilmington & Weldon Railroad	5	21	52	....	....	.....	24	26	.....	1,307	2	25	1,594	....	82	22	3,279	109	4,993	4,848	63	....	.....	....
Salem	....	.....	....	....	....	.....	....	....	.....	.....	....	....	.....	....	.....	.....	.....	....	.....	.....	.....	....	.....	....
Total, 1877	126	1,122	570	192	32	8,009	104	252	13,194	16,445	394	69	660,218	36	2,162	598	3,535	898	146,396	39,372	31,889	805	11,006	501
Total, 1876	....	1,039	61	108	43	8,778	16	124	1,199	2,610	....	44	3,532	50	15	1,007	298	58	3,553	1,349	.....	....	.....	....
Total, 1875	....	224	40	44	12	7,430	....	....	186	1,360	....	....	1,318	....	.....	1,841	.....	....	438	.....	.....	....	.....	....
Total, 1874	....	.....	714	285	....	9,714	....	....	617	3,111	....	....	2,363	....	.....	332	600	....	.....	.....	.....	....	.....	....

Amsterdam																									
Antwerp																									
Arvoyo																									
Barcelona																									
Belfast																									
Bremen																									
Bristol																									
Cardenas										1,018					6										
Cardiff																									
Cette																									
Cienfuegos																									
Cape Haytien																									
Channel, for orders																									
Demerara																									
Fajardo						13				209				541	62	1				100					
Genoa																									
Glasgow																									
Guyenella																									
Greenock																									
Havre																									
Humacao																									
Havana										95										1					
Hamburg																									
Hull																									
Halifax																									
Hayti																									
Saint Marc																									
Petit Goave																									
Gonaives																									
Anse de Hinault														69											
Aux Cayes																									
Jacknel																									
Jeremie																									
Laguayra																									
Liverpool																									
London																									
Marseilles																									
Moule																									
Mayaguez																									
Navassa Guano Company																				260					
Nassau																									
Naples																									
Newcastle																									
Point a Petre										87				7											
Ponce																									
Port au Prince																									
Rotterdam																									
Saba																									
Stettin																									

Statement of the principal articles of produce and manufacture exported from the port of Wilmington, N. C., &c.—Continued.

FOREIGN—Continued.

Destination.	Packages.																	Bags.						
	Paper stock.	Roots and herbs.	Tobacco.	Beeswax.	Furs.	Shooks.	Rope.	Fruit.	Dried fruit.	Empty casks, barrels, &c.	Lard.	Bones.	Merchandise.	Feathers.	Bacon.	Paper.	Cotton-ties.	Coffee.	Guano.	Salt.	Corn.	Rough rice.	Meal.	Asbestos.
Saint Martin's and Nevis																								
Saint Pierre																								
Saint George																								
Saint John, P. R.																								
Saint John, N. B.																								
Saint Stephen																								
Trieste																								
Total, 1877						13				1,309			617	62	7				361					
Total, 1876										1,658			34						48					
Total, 1875										511														
Total, 1874										150														
GRAND TOTAL.																								
Total domestic and foreign, 1877	126	1,122	570	192	32	8,022	104	252	13,194	17,754	394	69	660,835	98	2,169	498	6,535	898	146,757	39,372	31,889	805	11,006	501
Total domestic and foreign, 1876		1,039	61	108	43	8,778	16	124	1,119	4,268		44	3,532	40	15	1,007	298	58	3,553	1,349				
Total domestic and foreign, 1875		224	40	44	12	7,430		186		1,861			1,719			1,841			438					
Total domestic and foreign, 1874			714	285		4,714		617		3,261			2,353			332	400							
RECEIPTS.																								
Total, 1877																								
Total, 1876																								
Total, 1875																								
Total, 1874																								

Number of vessels and tonnage for 1877.

Steamers.			Barks.			Brigs.			Schooners.			Totals.			
Nationality.	No.	Tonnage.	Nationality.	No.	Tonnage.	Nationality.	No.	Tonnage.	Nationality.	No.	Tonnage.	Vessels.	Nationality.	No.	Tonnage.
American....	164	146,482	American...	2	907	American...	15	8,823	American...	137	80,750	Steamers	American...	164	146,482
			Norwegian..	78	25,493	Norwegian..	23	6,237	British.....	4	633	Sailing-vessels...	....do	154	35,480
			German.....	42	15,976	German.....	13	3,289				....do	Foreign.....	249	80,072
			British	22	7,851	British.....	35	10,819							
			Swedish	11	3,787	Swedish	4	1,081							
			Spanish.....	5	1,823	Dutch	2	279							
			Russian.....	1	330	Spanish.....	6	1,491							
			Danish	2	613	Italian.....	1	370							

SPECIAL REPORT ON IMPROVEMENT OF THE MOUTH OF CAPE FEAR RIVER, NORTH CAROLINA.

UNITED STATES ENGINEER OFFICE,
Baltimore, March 27, 1878.

GENERAL: I have the honor to acknowledge the receipt of your communication of the 26th instant (addressed to Major Craighill), transmitting, for information and for report thereon, a copy of a resolution of the United States Senate, dated 22d instant, calling upon the Secretary of War for—

> Any information he may have in his department in relation to the improvement of the Cape Fear Harbor in North Carolina since the last report upon that improvement.

As Major Craighill's successor (temporarily), it devolves upon me to report as follows:

At the date of the last annual report of the Chief of Engineers, operations were being principally confined to filling in with stone upon the structure for closing the space between Federal Point and Zeke's Island, and known as the "New Inlet."

About 20,000 cubic yards of stone had then been delivered upon the work under the then existing contract. The contract time for this delivery expired on the 31st of December, 1877. The contractors at that time had, by pushing their work vigorously, delivered very nearly 50,000 cubic yards of stone in all, which amount was somewhat more than was required of them.

At this time (December 31 last) a balance of about $20,000 remained on hand, available for the continued delivery of stone.

Previous to this time it had become manifest that it was particularly desirable that there should be no suspension in the delivery of stone, as will be explained hereafter in this report, and bids were invited for continuing the work to the extent of available funds.

These bids were opened November 15, 1877, and a contract was executed for the delivery of 12,000 yards of stone for the sum specified above, or at the rate of $1.66⅔ per yard.

Work under this contract was commenced early in January last, and at the present date nearly 10,000 yards have already been delivered. It is expected that the contract will be entirely fulfilled on the 10th proximo, when all further work for the closure of the New Inlet must necessarily be suspended for want of funds.

In the last annual report it is stated:

> The closing work is as high as low-water for about two-fifths of its length, * * * but the full width has not yet been given it.

The 40,000 cubic yards of stone which have since been put on the work have brought the structure up to low-water mark over nearly its entire length, but it must still be said the "full width has not yet been given it."

The structure at low-water mark is not over about six feet in width, with ridges at points projecting above this level. The filling which had been done just before the date of the last annual report, and which constituted the two-fifths of the length referred to in the report, was mostly in deep water, varying from 10 to 18 feet in depth. The filling in this deep water was standing well; but very little, if any, settling having been observed, which was very encouraging at the time (1st of July last); and it may be remarked here that this deep filling has continued to stand with but little settling.

But when the shoaler water was reached, particularly on the second section of the work (1,588 feet in length), a very serious settling was almost immediately detected as the filling advanced. It has been quite fully explained in previous reports that the first step for the closure of the inlet consisted in putting an apron, composed of mattresses of round timber and brush, loaded with stone, entirely across the space in question. This apron varied in width from 45 to 70 feet, according to the depth of water at any particular point. The width of the apron on the second section of the work was uniformly 45 feet, and its line of direction was on what was known as the "six-feet shoal."

As the filling has continued over the entire work generally, but more noticeably over the shoaler portions, of which the second section is an example, the water has cut out a deep trench on each side of the work, and this seems to have been caused more by the pouring of the water *over* the structure than by any current along the sides. As a result of this, the entire work is left resting upon a ridge, and at the shoaler places the work has gradually settled as the water has found its way between the timbers forming the base of the structure.

The limit of scour seems to have been attained at the present time, and the depth to which it has reached is about 18 or 20 feet below ordinary low-water. This depth, however, is found only at quite a distance from the mattresses, and no settling has been observed at points where the mattresses were placed at a depth of 14 feet or more below ordinary low-water. As the entire base of the structure is, at the shoalest point, about 12 feet below low-water at the present time, there is reason to suppose that the settling has nearly ceased, especially if the theory be correct that the limit of scour, due to the overfall of water, has been attained. It will be seen at a glance from the above that this settling (unexpected in extent) has caused the original estimates for the quantity of stone required to complete the work to fall below the amount absolutely required. On the completion of the apron, it was estimated that 85,000 cubic yards of stone would be required to bring the closing work to high-water mark. This was in June, 1876. Since that date about 62,000 yards have been put in, leaving a balance of 23,000 yards yet due to fill the estimate. It is now estimated that nearly 80,000 cubic yards of stone will yet be required to complete the work to high-water.

It is no more than just and proper to add, however, that this discrepancy would not have been so large had it been possible to have prosecuted the work continuously.

I quote from a report made on the 11th of the present month, by Mr. Henry Bacon, the assistant in immediate charge of this work. He says:

As the work of stone-filling at the New Inlet dam has proceeded, the scouring on each side and adjacent to it has increased, and all those portions of the work which were placed in shoal water, embracing nearly all the second section (1,588 feet in length) and portions of the first and third sections, have been gradually settled by the water finding its way between and under the logs of the mattresses, so that the base of the work is nearly everywhere at least 12 feet below mean low-water.

This subsidence and scouring are undoubtedly favorable for security and permanence, but necessarily involve a larger expenditure of riprap than was expected. Experience has shown the necessity of giving a liberal top-width to the dam at high-water, and of large stone carefully placed on the top and sea-side surface of the dam.

In completing the work to high-water mark, the slopes must be filled with stone to the limit of the scouring in depth. This already seems to have reached its limit. No increase has occurred for several months.

The forces to be contended with in the closure of the New Inlet are well illustrated by the fact that in the present imperfect state of the dam the water on the river-side, toward the last of the ebb-tide, is sometimes 2 feet higher than on the sea-side.

When the water shall be completely shut off by the dam, the difference will at certain times probably amount to 3 feet.

In the light of all our experience, I would now estimate the amount of stone required to complete the dam to high-water mark at 80,000 cubic yards.

The good effect of the partial closure of the New Inlet is already apparent at the mouth of the river by the general increase of depth both at the "Rip" and the Bald-Head Channels.

No words are needed to show the propriety and necessity of granting the comparatively small amounts needed for the completion of this important work.

I concur with Mr. Bacon in all that I have quoted above. His estimate of amount of stone required to complete the closing work to high-water mark appears high, and I trust that it may prove higher than necessary; but he is daily at the point of operations, and has been during the past two years and more, and he has learned that due allowance should be made for the treacherous movements of the tides and sand on this particularly exposed shore.

Three important steps for the improvement of the Lower Cape Fear River, at and below New Inlet, have constantly been kept in mind by the officer who has been in charge of the work for the past seven years (and who is now but temporarily relieved from the charge of same), viz, the closing of New Inlet, the deepening of water on the bar at the old mouth of the river, and the restoration of the old channel behind the "Horseshoe," opposite the inlet, and known as the Snow's Marsh Channel.

Of these operations, the first and the third are mainly merely subsidiary to the accomplishment of the improvement of the bar.

From time to time, work to a limited extent has been attempted, both at the bar to assist nature in restoring the old depth of water, and at the "Horseshoe" to restore the old location of the channel. The restricted means at the disposal of the officer in charge of the work have caused these attempts to be but comparatively feeble; but the results have demonstrated beyond a doubt the correctness of the theory which prompted them. For the past two years the small amount of funds available, and the particularly exposed position of the New Inlet, have imperatively dictated the necessity of devoting every available dollar to the work at the inlet, in order to secure that which had already been attained at so great an expense.

While I am called upon merely to give information in relation to the improvement of the Cape Fear River, and am not specially invited to express any "opinion" on the subject, I will venture to say the following, and trust that I will not be considered presumptuous in so doing:

The officer in charge of the work, in his annual report in July last, stated: "Amount that can be profitably expended in fiscal year ending June 30, 1879, $160,000."

This amount at that time was considered absolutely necessary to make complete the work at the inlet, with the probability that a sufficient balance would remain to enable some steps to be taken for the accomplishment of the subsidiary operations referred to above.

Circumstances which have arisen since the date of said report have certainly not diminished the amount which can be used to advantage during the year in question.

On the contrary, the unlooked-for increase in the amount of stone required at the closing work at the inlet has proportionally increased the amount which can be used to advantage; and I greatly fear that the amount in question, if appropriated, will do no more than close the inlet, and secure properly the beach in its vicinity, while the minor operations remain neglected—operations which should go on at once, in order to

secure promptly to navigation the full fruits resulting from the main operation, viz, the closure of New Inlet.

I am, general, very respectfully, your obedient servant,

CHARLES B. PHILLIPS,
Captain of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

F 8.

UNITED STATES ENGINEER OFFICE,
Camp No. 1, *Falls Branch, New River,*
Pulaski County, Virginia, July 1, 1878.

GENERAL: I have the honor to submit herewith the annual report of operations for fiscal year ending June 30, 1878, for the work of river improvement under my charge temporarily.

Very respectfully, your obedient servant,

JAS. W. CUYLER,
Captain of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

IMPROVEMENT OF NEW RIVER FROM LEAD MINES IN WYTHE COUNTY, VIRGINIA, TO THE MOUTH OF GREENBRIER RIVER, WEST VIRGINIA.

Having been assigned by my predecessor in charge of the work, Maj. W. P. Craighill, Corps of Engineers, to its local charge, June 28, 1877, I took station at New River Depot, Pulaski County, July 6, after having first visited Wytheville, in order to obtain some necessary information and make certain needed arrangements, proceeding thereupon to inaugurate the work.

The project of Major Craighill, which was to form a clear channel, 30 feet wide by 2 feet deep, below minimum low-water, through the rock in place, constituting the "falls" and "ripples" in the river, and the coarse gravel constituting the "bars," such channel to be adapted to the existing navigation, *i. e.*, "keel-boats" or batteaux, with an average carrying capacity of 8 tons, on a draught of water 21 inches, and to be so arranged as to be capable of utilization, in the more general and permanent project contemplated, for a channel 90 feet wide by 3 feet deep, suitable for light-draught steamers, having been approved by the Chief of Engineers, June 7, 1877, I made a reconnaissance of the portion of the river extending 20 miles above and 7 miles below the determined-upon initial point of the work, *i. e.*, the bridge of the Atlantic, Mississippi and Ohio Railroad spanning New River, between July 7 and 15, 1877, with a view of fixing the several localities for work.

The engineering as well as local considerations, pointing to the advisability of carrying the work forward progressively entirely upstream, a gravel "flat" 16 feet long by 8 feet beam and a "stone-boat," with 4 canoes, were built; 2 keel-boats 50 feet long by 7 feet 9 inches beam, were hired for quarters and transportation; boats, tools, and supplies collected, and a working force organized by July 23, when work was begun on

the four ripples next above the railroad bridge and distant from it from 200 to 600 yards.

The nature of the work involved, for the removal of the rock in place, blasting under water as the method of working; "juniper-drills" were decided upon, as from the overhanging of the ledges and the fact that the workmen had to stand in quick and strong water, in order to drill, suitable "churn-drills" would have proved too unwieldy and heavy; holes of 2 inches diameter were fixed on as best suited to the work, and these were drilled on an average 3 feet below bed, and spaced as nearly equally apart as the lay of the rock would permit, varying from 2 feet to 8 feet

In view of the facts that the labor of the country composing the force was entirely ignorant of the method of handling dynamite or "giant-powder," and that I had not time before leaving Baltimore, my nearest point of supply for such explosives, to arrange for procuring them, I decided upon the use of the "Orange" blasting-powder, and after several experiments with tin cartridge-cases and gutta-percha and india-rubber patent tubing for same, finally selected the "pitch-bag" cartridge, a cylindrical bag of close ticking, made around a wooden core, and immersed in a mixture of pitch and tar of the proper consistency, with a piece of "double-tape" fuse inserted in the mouth and choked, which selection was followed by the best results, not 1 per cent. of blasts failing, as due to the cartridge, during the two and one-half month's operations of 1877. For the removal of the gravel-bars the pick and shovel were used.

Lying as the work did in a country sparsely peopled and relatively inaccessible, it became a necessity to feed and tent the entire working party. Working on the above plan, a party of 50 were worked during the season of 1877.

After finishing the four ripples above referred to to width and nearly the proper depth, and building training-walls and wing-dams at them with the rock excavated, a fifth ripple—a narrow ledge offering no serious obstruction—half-way between Ripple 4 and "Jones" (for reference to localities, *vide* survey-map of 1872), was cut through; a gravel-shoal 80 feet in length, opposite "Jones" was dug through, and lacking but a few inches of the requisite depth; a "gathering-dam," extending 110 feet up river, was put in, raising the water to the proper level without blasting, and the main work of the season reached the passage of Ingle's Falls 3½ miles above the railroad bridge.

These falls consist at head of eight distinct ledges of hard gniess rock, running straight across the river, successively, for 600 feet, barring back a pool extending up 3½ miles, with from 9 feet to 3½ feet water in it; below these ledges for 350 feet extend large detached bowlders, through which the natural sluice winds with great velocity of flow, succeeded by a gravel-shoal 240 feet in width, the "falls" being terminated by another gravel-shoal 300 feet wide just above the broken-down piers of the old Virginia and Tennessee Turnpike Bridge, in themselves, as they stand, an obstruction to descending boats, which latter require the removal of certainly the westerly pier of the two; the stretch of river embraced in the "falls" is 1,010 yards, and the total fall in this distance 7.11 feet, the width of low-water bed at head being 700 feet, narrowing suddenly at the lower "gravel" to 530 feet. Three-fourths of this fall of 7.11 feet occurs in the upper 900 feet through rock; and the gravel-shoals below, as well as the generally rough and irregular nature of the entire bed of the lower section, are undoubtedly due to the abrupt change of slope in the bottom, occasioning all the particles brought down through the rock-falls to be dropped in the sinuosities of the natural sluice.

Through the entire course of these obstructions, a channel-way of the prescribed dimensions was formed, and from an examination made last month, after the experience of the ice and freshets of the winter and spring ice, there are no decided signs of the filling in of the cut through the "gravel."

The working section, at Falls Branch, 4½ miles above Ingle's Falls, was next commenced upon. This work, lying on the convex side of a deep horseshoe bend, consists at head of falls of five rock ledges running across the river; vertical fall 3 feet 6 inches succeeded below by deep pool of still water, cut diagonally across as the river bends by longitudinal ledges, the lower section consisting of rock ledges, straight across, again terminated by an abrupt fall over a gravel- bed; fall in this lower section 4 feet to surface of pool extending up from "Ingle's"; width of low-water bed 900 feet narrowing to 670 feet in bend, and total length in river of the obstructions 1 mile. The rock here, a disintegrated slate, blasting but very badly, proved so troublesome, that but little progress was made, and on October 11, high water and cold weather setting in, work had to be abandoned for the season, and the property put in store at the railroad bridge.

The work of the season had been of a character before untried, and to a certain extent experimental, but what had been done having proven that the project adopted was fully capable of meeting the object held in view by it, with the exception of following invariably the natural sluices and channels, if the present work was to be utilized in the more general project proposed, the winter was devoted to preparing a complete outfit suitable in character for operating on a larger scale. The lack of "plant," transportation, tents, &c., had closely restricted the operations of 1877 by itself, even had there been no other reason to conduct the work tentatively, and a party of 50 was the maximum for advantageous working in the season of 1877. Plans were made for a special class of boats adapted to the work in hand, on which six boats were built, including a "crane-boat," with light machinery; and all preparations being complete by June 1, on June 14 the work of the season was begun, the delay being due to the unusual high stage of water in the river and constant violent rains. The completion of the "Falls Branch" section, the terminus of last fall, was taken in hand and is at date completed.

After the close of work on October 11, 1877, a small field-party made the necessary surveys for enlarged maps of localities worked at, which should show details and changes which the survey of 1872 did not exhibit.

On October 22, I made a series of gaugings of the river extending to October 30, the point selected being at and below Ingle's Falls, this point being chosen not so much with an eye to the regularity of river section, but because it was the most serious obstacle to navigation, on the line of the season, and was a characteristic type of that class of obstructions—the worst in the river—it was desired to ascertain, with as near a degree of approximation as the nature of the case would permit of, the amount of obstruction to steam navigation of the river.

The observations were made with tin ellipses, submerged to various depths, and wooden floats; and while numerous observations were made with all the care practicable, the nature of the stream itself and the particular locality rendered solutions within exact limits impossible. From the measurement and the formulas used, good approximate results were obtained, showing the mean velocity of the river at this point to be about 5¼ miles, and the discharge equal to about 900 cubic feet per second, with a gauge-reading of 7.75 inches. For a more complete solution

a series of gaugings should be continued at various stages of the river, and a connection made with the more permanent gauge-boards established in the lower New River, a mean distance of 100 miles below the site of this work, and referred to the Charleston (Kanawha) plane.

The above-given figures furnish all requisite information for immediate practical purposes; for more exact results, observations extending over some time and nicely conducted are required, so great and so sudden are the variations in the stages of this river, and so many anomalous features does its upper course of 128 miles present.

The rocks passed through in excavating, consist mainly of the common limestones, often holding fine crystals of dog-tooth spar and slates.

At Ingle's Falls the rock was almost entirely a hard, tough gneiss. The limestones are often found partially disintegrated, and more often the slates, the latter, when lying in nearly horizontal beds, proving a very troublesome and costly bed to excavate, as involving quarrying after blasting, or blowing out in small fragments; the gravel in the river is large and may better be termed a "shingle." As a rule, the excavations have furnished about the necessary material for the dams, training-walls, &c., in which no brush has as yet been worked, the inner constructions of this material, with stone by private parties, for special, local objects, and by the government of the States lately in rebellion, not having proved stable or satisfactory.

It is proposed in the further progress of the work, to use more extensively the gathering-dams and training-walls, as a means of securing the necessary depths, with a diminished amount of blasting; also to use, in certain cases, "giant-powder" as an explosive, and introduce the use of the churn-drill.

As a general description of this upper New River, it may be said to consist of a series of pools from 100 feet to 4 miles in length, with from 3 feet to 10 feet depth in them, some few points, "holes," showing 20, 30, and more feet. These pools are separated by ledges straight across or diagonal to the river, in groups of from 5 to 10. The total fall between pools rarely exceeds 7 feet, more often 3 feet or 4 feet, the actual vertical fall, not frequent, at a single ledge scarce ever being more than 18 inches; in fact, the so-called "falls" should be more appropriately termed "rapids."

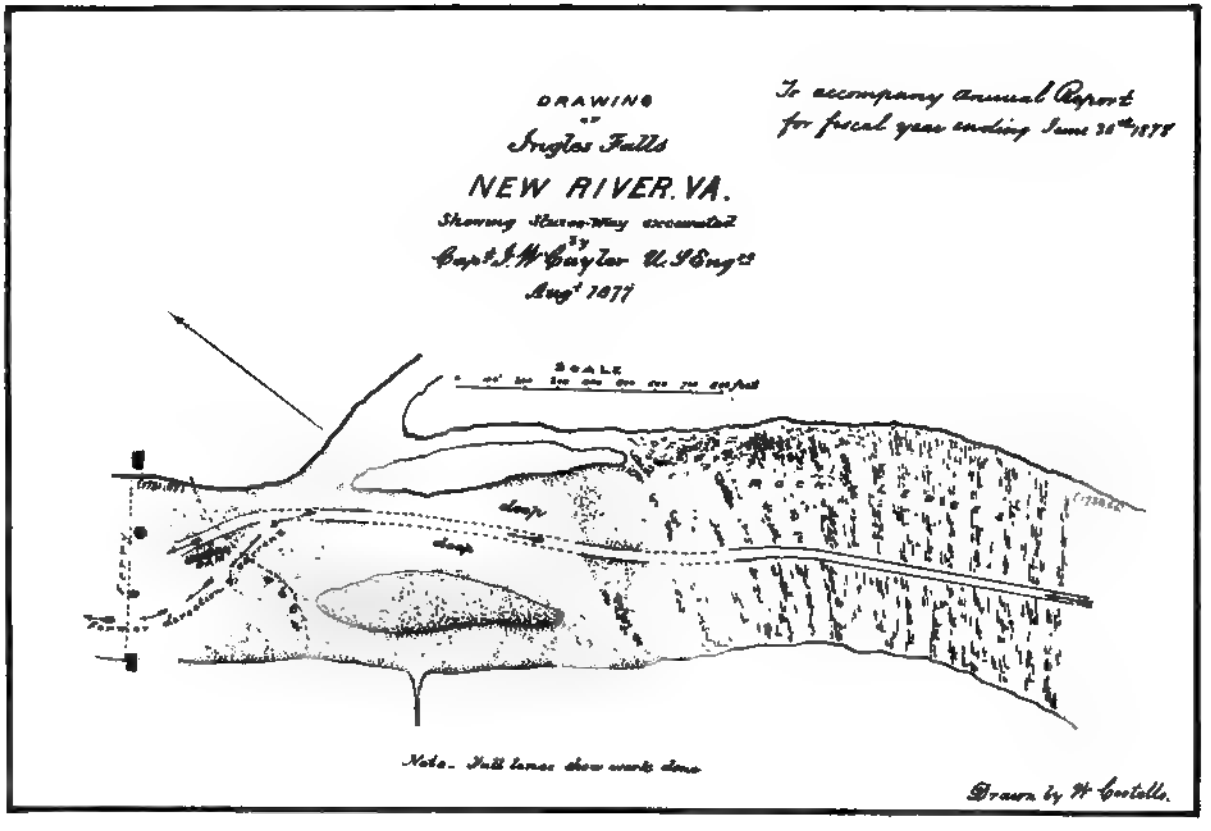
There are some stretches of river showing long shoals, not bars, of the coarse gravel, but the pools and rock ledges predominate, pockets of gravel being generally found in and at foot of the "rapids." With such a regimen any improvement made as to deepening and widening the channel introduces the new obstacle of largely-increased velocity and volume; so that though the main and more important navigation of this river must ever be that of descending boats, yet no scheme of improvement can fully meet the requirements of the case without considering and aiming to counteract this induced obstacle to navigation.

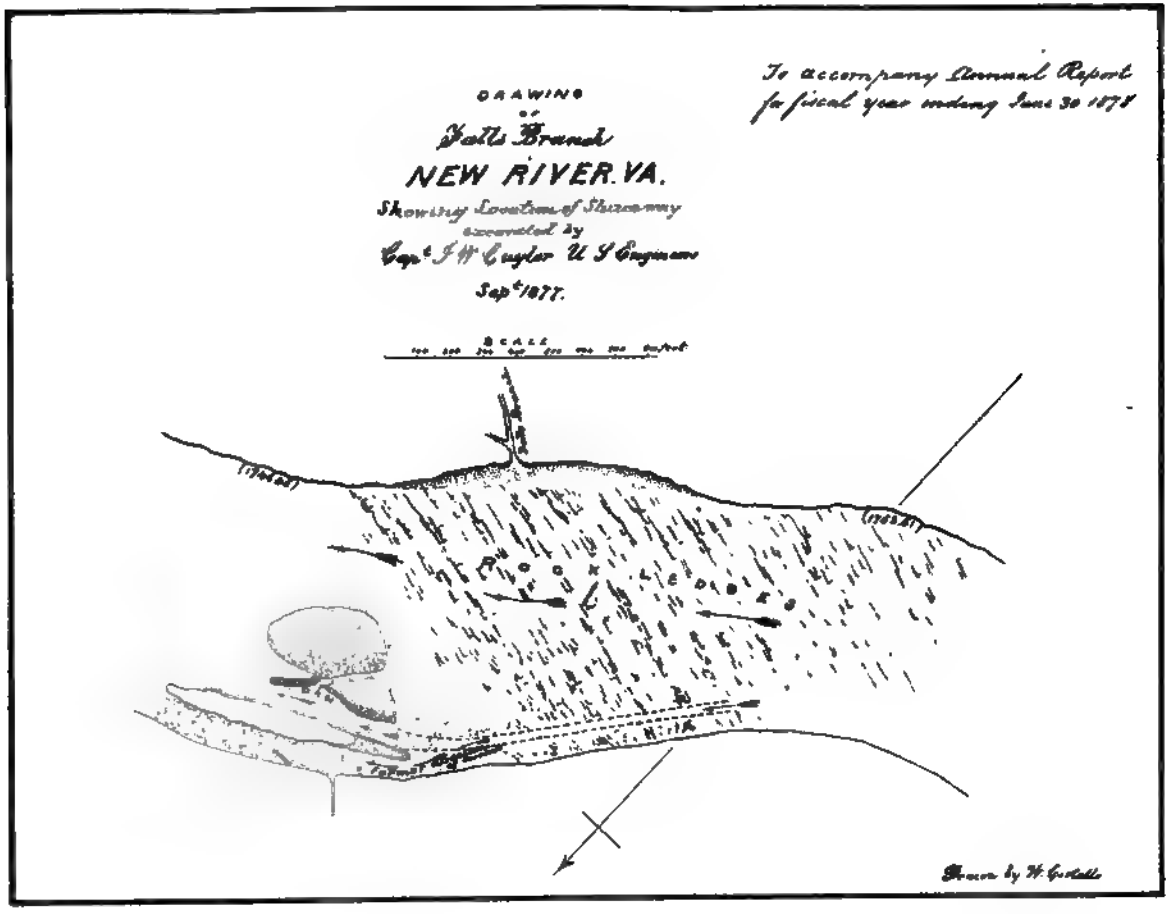
Appended will be found tabular statements exhibiting figures of work, localities of same, and gauge-readings for the season of active operations of 1877–'78.

From the first table it will be seen that the work has been done at figures considerably below the estimates of the report of 1873, the general lowering of prices for labor and supplies of course largely affecting this, as also the favorable season for work shown by the gauge-tables.

With a gauge-reading of + 12 inches, which is the usual river's stage from November 1 to May 15, operations of the kind being carried on are impracticable.

As to the amount of work to be done for either the 30 feet or 90 feet


DRAWING
of
Ingles Falls
NEW RIVER. VA.
Showing Sluice-Way excavated
by
Capt. J. W. Cuyler U. S. Engrs
Augt 1877
To accompany Annual Report
for fiscal year ending June 30th 1878
SCALE
deep
deep
Note. Full lines show work done
Drawn by W. Costello.

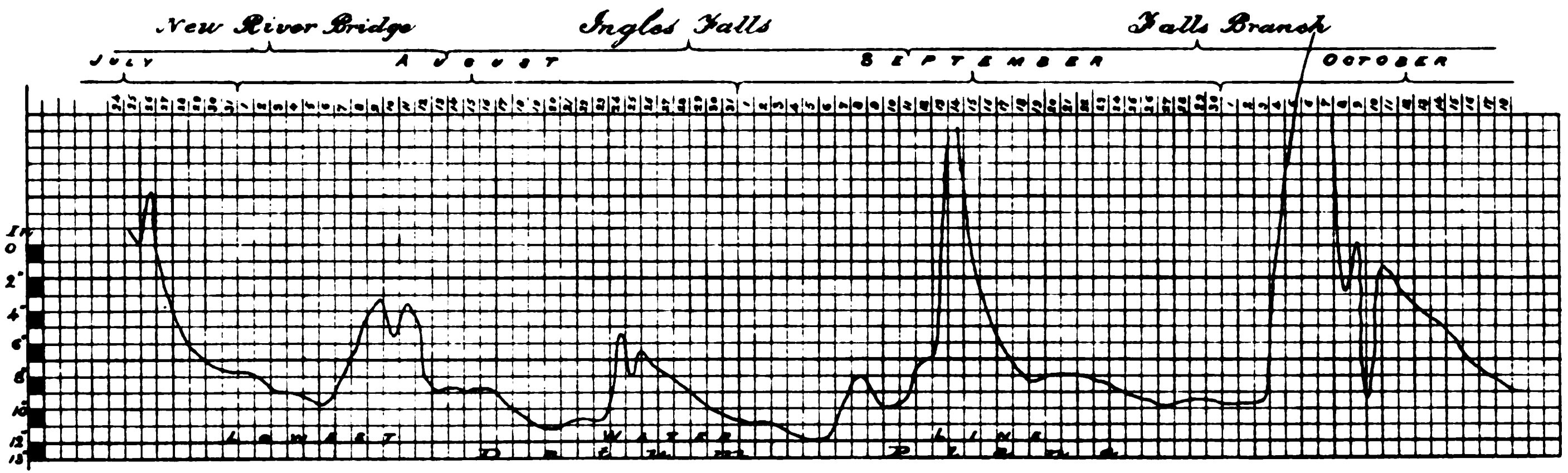

To accompany Annual Report
for fiscal year ending June 30 1878
DRAWING
OF
Falls Branch
NEW RIVER. VA.
Showing Location of Shiroomy
excavated by
Capt. J. W. Cuyler U. S. Engineers
Sept. 1877.
SCALE
ROCK LEDGES
Drawn by W. Gistelle

Water-gauge

NEW RIVER, VA.

1877.

To accompany Annual Report for fiscal year ending June 30 1878.



Drawn by H Gostelle

width of channel-way, the experience of the year leads me to conclude that the estimates, as set forth in the report of 1873, are below considerably the actual amounts required.

Sketches of the more important working sections, Ingle's Falls and Falls Branch, are appended.

DETAILS OF WORK DONE 1877–1878.

Rock excavated and moved	cubic yards..	724
Gravel excavated and moved	cubic yards..	775
Number of holes drilled		1,044
Number of feet of holes drilled	feet..	3,027
Average depth of holes	feet..	2.9
Average depth of hole (2 inches) drilled per day per drill	feet..	9.75
Number of blasts fired		984
Number of blasts missed		60
Number of cartridges made		1,076
Average charge of powder in each cartridge	pounds..	⅝
Average loosening of rock per blast	yards..	¼
Average cost of pitch-bag cartridge completed		$0 19.5
Average cost of rock excavation, including blasting, scowing away *débris*, and building same into training-walls, &c	per yard..	$3 50
Average cost of gravel for do	per yard..	$0 70

STATEMENT SHOWING LOCALITIES OF WORK DONE 1877–78 AS PER SURVEY-MAP OF 1872.

	Width across of ledge.
1. 200 to 600 yards above railroad bridge—	
Ripple No. 1	50 feet.
Ripple No. 2	110 feet.
Ripple No. 3	20 feet.
Ripple No. 4	20 feet.
2. Ripple No. 5 between Ripple No. 4 and "Jones"	20 feet.
3. Gravel shoal opposite "Jones"	80 feet.

	Total length of falls and rapids in river.
4. Ingle's Falls	½ mile.
5. Falls Branch	1 mile.

Money statement.

July 1, 1877, amount available	$14,921 75	
Amount appropriated by act approved June 18, 1878	15,000 00	
		$29,921 75
July 1, 1878, amount expended during fiscal year		6,492 26
July 1, 1878, amount available		23,429 49
Amount (estimated) required for completion of existing project		70,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		35,000 00

APPENDIX G.

ANNUAL REPORT OF MR. S. T. ABERT, UNITED STATES CIVIL ENGINEER, FOR THE FISCAL YEAR ENDING JUNE 30, 1878.

UNITED STATES ENGINEER OFFICE,
Washington, D. C., August 8, 1878.

GENERAL: I have the honor to submit herewith my annual report relating to the works of river and harbor improvement under my charge for the fiscal year ending June 30, 1878.

Very respectfully, your obedient servant,

S. T. ABERT,
United States Civil Engineer.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers U. S. A.

G 1.

IMPROVEMENT OF HARBORS AT WASHINGTON AND GEORGETOWN, DISTRICT OF COLUMBIA.

At the commencement of the fiscal year the appropriation of $50,000, (made March 3, 1873), for the improvement of the harbors of Washington and Georgetown, had been expended in dredging channels above and below the Long Bridge, and in removing dangerous rocks in Georgetown Harbor, leaving a small balance of $2,800, which was insufficient for any work which could materially benefit the navigation of the river; the work, therefore, has remained practically suspended during the year. The new channel had, however, under the action of the annual freshets, been undergoing gradual deterioration. This has been anticipated in former annual reports on this work, in which it was stated that the bar would probably re-form every three or four years, unless the flats were inclosed and the river-width contracted. The river at this point increases from 900 to 5,000 feet in width; the freshet-water loaded with sediment, leaving the confined channel above Georgetown, suddenly expands over the wide area below. The resulting decrease in the velocity of the stream, which is still further checked by the flood-tidal current, causes a deposit of the material held in suspension. This action had, however, been comparatively gradual until the freshet of November 25, 1877, which continued for three days, and which exceeded any previous freshets of which we have any record. Much damage was caused to the shipping and wharf property in Georgetown, and the causeway between Analostan Island and the Virginia shore was partly carried away. The heights of the freshets at different points were as follows:

	Feet.
New outlet-lock, Chesapeake and Ohio Canal	19.8
Aqueduct Bridge, Georgetown	16.5
Wharf of Philadelphia steamer, Georgetown	13.6
Foot of F street, N. W., Washington City	13.0
Foot of Seventeenth street, Washington City	10.2
Long Bridge, Virginia draw	9.0
Arsenal Point	8.4

These heights were determined by marks fixed by observers. When the freshet had subsided, the depth of water on the bar was found to have been greatly reduced. The least low-water depth over the bar was about 9 feet, where 15 feet depth had existed in 1875. When coal shipments were about to be resumed in the spring of the present year, steps were taken by the merchants and the coal companies of Georgetown to dredge a temporary channel through the bar, to meet the more pressing wants of navigation, until relief should be afforded by Congress. Subscriptions were made by parties interested, and several cuts were dredged in the shoalest part of the bar. Application was made by the citizens executing this work, for the expenditure of a part of the available balance in widening this channel, and authority for the same was granted by the Chief of Engineers. Proposals for the work were invited, and the following bids were received and opened April 24:

No.	Name.	Address.	Price per cubic yard.	Time of commencement.	Time of completion.
1	G. H. Ferris	Baltimore, Md	.28	May 10, 1878	June 30, 1878
2	H. P. Gilbert	Georgetown, D. C	.20	At once	June 1, 1878

The contract was awarded to Mr. H. P. Gilbert, of Georgetown, who commenced dredging May 7 and completed the work authorized May 21, 1878, removing 5,500 yards.

During part of April and May, 1878, a survey was made of the part of the river between Easby's Point and the Arsenal, to ascertain the changes caused by the freshets; all the data then obtained will be found in the maps accompanying this report.

AUTHORIZED OPERATIONS FOR THE RELIEF OF NAVIGATION.

The following appropriations were made in the river and harbor act, approved June 18, 1878, for the continuation of this improvement:

For improving the harbors and channels at Washington and Georgetown, District of Columbia, fifty thousand dollars, of which sum twenty thousand dollars is to be expended in Washington Harbor and Channel below the Long Bridge, and thirty thousand dollars to be expended in Georgetown Harbor and Channel.

In accordance with these provisions, specifications have been prepared for a channel 200 feet wide and 16 feet deep at low-water, through the bar below Easby's; and also for dredging a channel 200 feet wide and 12 feet deep at low-water, along the Washington wharves. The work has been advertised for proposals, and will be commenced at an early date.

THE PERMANENT IMPROVEMENT OF THE RIVER.

In order that the channel to be dredged may be rendered permanent, it is important that a general plan of improvement should be adopted, and that its continuation should be provided for by annual appropriations sufficiently large to insure substantial progress in the work.

Three plans were discussed by the Board of Survey appointed by act of Congress, for the permanent improvement of the harbors of Washington and Georgetown:

First. That of a single channel following the Washington shore between Easby's Point and the Arsenal.

Second. A channel following the so-called Virginia Channel.

Third. The retention of both these channels—the Washington Channel

to be employed as the main channel for navigation; the Virginia Channel to be used as an outlet for the flood-water—and the area between them to be reclaimed and raised above the highest flood.

The second of the above-mentioned plans can be executed at less cost than either of the others; it affords easier curves for the discharge of the water and will require a less expenditure for the preservation of its depth. This plan was, therefore, recommended by the Board of Survey and has been described in previous annual reports; the work already executed for the relief of navigation has been in accordance with this plan as required by the act making appropriations therefor.

In my reports for the years 1875 and 1876, it was proposed to secure the radical improvement of the river, by the successive execution of parts of the general plan of the Board of Survey, each part being selected with reference to its relative importance and its relation to the succeeding parts, so that each division of the work would be in itself a decided improvement of the navigation, and would, at the same time, facilitate the economical completion of the entire plan. The initial work, according to this proposition, would have been confined to a rectification of the curvature, between the aqueduct and Easby's Point, to be effected by the cutting off of the northern and eastern sides of Analostan Island, and also of the eastern front of the river between G street and Easby's.

The estimates for this work will be found in the Report of the Chief of Engineers for 1875, Part II, page 119, and in the Report for 1876, Part I, page 346.

Upon examination it was found that a large amount of rock would have to be excavated, and the cost of land damage would also have to enter the estimate and would increase the original estimate of the Board. These recommendations did not receive the sanction of Congress. I would, therefore, submit the following plan:

Instead of the execution of the proposed plan of the Board in successive divisions, I would now propose to limit the work to the essential features of this plan by confining the operations to the dredging of a channel, following the course of the Virginia Channel, between Easby's and the Arsenal, and reclaiming the entire area between the city front and the river channel, leaving the question whether this area should be parked or laid out in city lots for future consideration.

The compensation for injury to riparian rights can be made according to the plan suggested further on.

The importance of a radical improvement of the river to the health and prosperity of the city, cannot be disputed, and its early completion will afford the only satisfactory solution to questions relating, first, to the sanitary condition of the city; second, to the relations of labor to capital; and, third, the much needed improvement to trade and navigation.

1ST.—SANITARY CONDITIONS.

The flats above and below the Long Bridge have been gradually shoaling for many years by reason of the deposit of sediment from freshets; an area of more than 300 acres is now left bare at every low tide, and the depth on the remainder of the flats is, at this stage, from 1 to 3 feet, increasing toward the river channel.

The shoaler portions are thickly grown with aquatic grasses, which undoubtedly increase the deposition of silt. There can be no question but that the flats, alternately exposed and covered by the tides, seriously affect the health of the city; and sanitary as well as commercial considerations alike demand the early abatement of this nuisance.

2D.—THE LABOR QUESTION.

The increasing population of artisans and laborers requires an increase of the employments which are independent of the annual appropriations of Congress, and this desirable end can be best attained by the improvement of the facilities of trade and navigation which will open a larger field of employment for laborers and artisans.

3D.—TRADE AND COMMERCE.

The commerce of the port of Georgetown requires a wide and deep channel. The largest shipments are those of Cumberland coal brought down by the Chesapeake and Ohio Canal, which is sent to northern and eastern cities in sailing-vessels. A deep channel permits the use of large vessels and materially reduces the cost of transportation. The statistics appended to this report show fully the amount and character of the trade of this port.

The Board proposed to obtain these ends by the adoption of the second of the above-mentioned plans, and it is to the modification of this plan, by which its most important object can be economically secured, that I now respectfully call your attention.

THE FILLING OF THE FLATS.

The material which it is necessary to dredge from the river in order to secure a permanent channel is largely sand, which is suitable for filling the flats, and can be deposited on them at a lower rate per cubic yard than material from the shore, and will thus serve a double purpose. The height of the filling should be regulated by the height of the highest freshet. The average height of the flood of November 5, 1877, between F street and the Arsenal was 10.4 feet above low-water. A grade, therefore, of 11 feet would be ample if a sufficient cross-section is maintained for the discharge ot the river at high-water.

SEWERAGE OF RECLAIMED GROUND.

As the filling of the flats progresses the disposition of the present city sewerage will require attention. This subject was considered by the board of survey, who referred to it as follows:

The sewerage of this reclaimed land would, in general, present no difficult problems. To this there is one exception, viz, the discharge of the great intersecting sewer running along B street northwest from Seventh street west to Seventeenth street west. The bottom of the sewer is now —— inches below mean low-water. This sewer should be continued by the most direct line in length 3,000 feet to the bulkhead, having an average width of 20 feet, a height of 9 feet, with its bottom 2 feet below mean low-water at Seventeeth street and 5 feet at the bulkhead. This sewer would then at all times contain nearly 6,000 tons of water, with a tidal flow in and out of 10,000 tons daily. If the area drained has 80,000 inhabitants, the amount of organic matter would be 20 tons; the tidal water would amount to five hundred times this amount, sufficient to render it inoffensive. But this sewer would have to be periodically cleaned.

The most efficient method would probably be to provide intercepting sewers for all higher levels to discharge into the river by gravity; and for the lower districts to be provided with special sewers, and with pumping stations near the river-channel, which will raise and discharge the sewerage at such levels as the stage of water may require. For the district now drained by the B street sewer, at the foot of Seventeenth street, the line suggested by the board will probably be the most economical.

A perfect system of sewerage could be secured for the low district by placing pumping-engines, one on the new river front on the prolongation

VIRGINIA

of Seventeenth street; the other at the outlet of James Creek Canal, about half way between the Arsenal and the navy-yard. At the present time one pump at the last-named locality would be sufficient to drain the sewers at all stages of the water.

NEW BRIDGE.

When the channels have sufficiently progressed, some provision will also be necessary for the construction of a bridge in the place of the present Long Bridge, with piers sunk to the depth that the new channels will require, and with spans and draw which will meet the requirements of navigation, as recommended by the board of survey in their report.

RIPARIAN OWNERS.

The filling of the flats and Washington Channel between the Long Bridge and the Arsenal will involve the destruction of the wharves along this part of the city front.

It will be necessary, therefore, to keep the Washington Channel open for navigation until the new frontage shall have been completed, when the riparian owners might be granted an equivalent frontage and area of land upon the new and deeper channel; the old channel could then be filled without detriment to navigation.

At and above Easby's Point the changes proposed by the board for the reduction of the curvature of the channel are of great importance, but, as the excavation would be very expensive, the work may be limited to the removal of Easby's Wharf and the rock near the house of the Analostan Boat Club. The dimensions of the new channel would be regulated by the cross-section required for the discharge of the river at high-water.

The following table gives the principal dimensions of the channel and the present and proposed cross-section:

Locality.	Surface width at low-water.	Maximum low-water depth.	Height of freshet of 1877.	Approximate sectional area.		Proposed sectional area at low-water.
				At low-water.	During freshet of 1877.	
	Feet.	*Feet.*	*Feet.*	*Square feet.*	*Square feet.*	*Square feet.*
Aquednct Bridge.....	900	29.	16. 5	20, 433	35, 253	No change at present.
G-street wharf	1, 080	31.	13. 0	22, 730	42, 080	Do.
Easby's Point	930	37.	.....	20, 275	.....	Do.
Seventeenth-street wharf to Gravelly Point.	5, 330	14. 3	10. 2	20, 640	75, 414	30, 125.
Long Bridge.....	2, 497	29.	9.	26, 012	48, 662	33, 550.

The general plan of the improvement above referred to provides for the ultimate and permanent improvement of the two harbors by the dredging of a wide and deep channel and filling the flats with the dredged material.

I submit with this report a modified estimate providing for the excavation of a channel 20 feet deep at low-water along the deeper portions of the river, and a channel 15 feet deep adjacent, following substantially the lines laid down by the board of survey. It is proposed to confine the material dumped on the flats, by means of a riprapped slope, with a protection of sheet-piling at the low-water mark, as shown on the plan accompanying this report. The cost of construction of wharves would properly be sustained by the riparian owners.

The channel above proposed will provide for a low-water sectional area at that part of the river where the bar now forms about 30,000 square feet, being somewhat greater than the present low-water section between the Aqueduct and the Long Bridge. The width of the river will be decreased by the proposed bulkhead lines so as to insure the preservation of the depth at low-water stages, and at the same time afford a sectional area during freshets 5,000 feet greater than that at the Long Bridge.

The estimated cost of the work now proposed as the project for the improvement of the Washington and Georgetown harbors is as follows:

14,940,000 cubic yards dredging, at 15 cents	$2,241,000	00
23,000 feet of slope protection, at $4	92,000	00
Crib-work, &c., at east end Long Bridge	23,000	00
Contingencies	236,000	00
	2,592,000	00

The improvement can be commenced and carried on gradually by the appropriations of $150,000 to $200,000 for each year; such appropriations will insure a low contract-price per cubic yard and substantial progress each year until the accomplishment of the work.

EXAMINATION OF ROCKS AT CANAL OUTLET ABOVE GEORGETOWN.

I had the honor to submit on March 27, 1878, a report upon the cost of removing rocks near the outlet lock of the Chesapeake and Ohio Canal in answer to a resolution of the House of Representatives referred to me by your letter of March 20, 1878. The rocks which require removal are in one group in front and nearly on the axis of the new outlet lock of the Chesapeake and Ohio Canal, about 250 feet from the foot of the incline.

The rock is partly out of water at low tide, and although there are channels on each side it will be found a serious obstruction to the large amount of trade passing out of the canal. The estimated cost of removing the rocks to the depth of 9 feet at low-water will be as follows:

1,600 cubic yards of rock excavation, at $25	$40,000	00
Contingencies, 10 per cent	4,000	00
	44,000	00

The following statement gives approximately the trade of the two harbors during the past fiscal year:

STATISTICS OF TRADE OF THE PORT OF GEORGETOWN, D. C.

Received by canal.

Bituminous coal	tons	485,000
Wheat	bushels	1,400,000
Corn	bushels	200,000
Flour	barrels	20,000

Received by river.

Hard coal	tons	25,000
Wood	cords	3,000
Ice	tons	18,000
Yellow pine lumber	feet	6,000,000
Shingles		1,000,000
Pickets and laths		4,000,000
Cedar posts		7,000
Miscellaneous (by steamers)	tons	25,500
Calcined plaster	barrels	7,000

Lump plaster	tons..	2,000
Guano	tons..	7,500
Salt	sacks..	16,000
Potatoes	bushels..	10,000
Wheat	bushels..	150,000
Fish (Boston packet)	barrels..	10,000
Miscellaneous (Boston packet)	tons..	2,000

Shipped by river.

Bituminous coal	tons..	475,000
Including flour (by steamers)	tons..	33,750
Empty barrels		210,000

STATISTICS OF TRADE OF THE PORT OF WASHINGTON, D. C.

Received by canal.

Bituminous coal (gas company)	tons..	6,000
Bituminous coal (trade)	tons..	40,000

Received by river.

Bituminous coal (gas company)	tons..	12,000
Pipe retorts and fire-brick (gas company)	tons..	11,500
Hard coal (trade)	tons..	150,000
Wood (trade)	cords..	25,000
Ice (trade)	tons..	35,000
Oysters (trade)	bushels..	210,000
Salt fish	barrels..	7,500
Hay and straw	tons..	7,000
Potatoes	bushels..	12,000
Yellow-pine lumber	feet..	15,000,000
Laths and pickets		10,000,000
Shingles		6,000,000
Posts		10,000
Granite and other stone	tons..	4,600
Miscellaneous (by steamers)	tons..	7,000
Miscellaneous (by ferry)	tons..	1,500

Shipped by river.

Oil, pitch, and tar (gas company)	tons..	6,500
Miscellaneous (by steamers)	tons..	14,000
Other miscellaneous freight	tons..	3,000
Empty barrels		30,000

Also a large amount of fresh fish, watermelons, sweet-potatoes, and other vegetables.

The following maps and plans accompany this report:

One map of the harbor between Easby's Point and the Long Bridge, scale $\frac{1}{3000}$.

One map of harbor below Long Bridge showing Washington Channel and adjacent flats, scale $\frac{1}{5000}$.

One general map of the harbor showing its present condition and the proposed improvement.

One general map of the harbor showing its condition after the completion of the proposed improvement.

One plan showing the proposed method of protecting the slope.

Money statement.

July 1, 1877, amount available	$2,856 62	
Amount appropriated by act approved June 18, 1878	50,000 00	
		$52,856 62
July 1, 1878, amount expended during fiscal year		2,778 40
July 1, 1878, amount available		50,078 22
Amount (estimated) required for completion of existing project		2,592,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880		244,000 00

REMOVAL OF ROCKS AT OUTLET OF THE CHESAPEAKE AND OHIO CANAL, DISTRICT OF COLUMBIA.

UNITED STATES ENGINEER OFFICE,
Washington, D. C., March 27, 1878.

GENERAL: In accordance with the instructions contained in your letter of the 20th instant, I have the honor to submit a report upon the following resolution of the House of Representatives of March 14, 1878:

Resolved, That the Secretary of War be, and he is hereby, requested to ascertain the probable cost of the removal of the rocks in the channel of the Potomac River between Georgetown, District of Columbia, and the new outlet locks of the Chesapeake and Ohio Canal, above said Georgetown, and report the same before the close of the present session of Congress.

One of the rocks referred to in the resolution is situated in front of and on the line of the axis of the incline of the new outlet lock of the Chesapeake and Ohio Canal, and about 250 feet distant from the foot of the incline. A part of the rock is above low-water, the depth on the remainder varying from 1 to 10 feet at low-water. The depth of water between the rock and the shore is from 11 to 12 feet, and between the rock and the foot of the incline from 16 to 18 feet. Canal-boats can be taken into the main part of the river by either of two channels around this rock, but with a large amount of business it would doubtless be found a serious obstruction to the safe handling of boats and tugs.

A special examination of the rock has been made, and a bench-mark for low-water established at the lock.

The depth required for tug-boats is 9 feet at low-water, and an estimate has therefore been made for the removal of the rock to the 9-feet curve. The estimated amount of rock excavation is 1,600 cubic yards.

In the determination of the probable cost of this work, the bids received for similar work in Georgetown Harbor in 1875 have been taken as a basis. These bids ranged from $19 to $37 per cubic yard. The work was executed at a cost below the lowest bid, by hired labor and machinery borrowed from another work. Experience demonstrated, however, that a contractor could not have purchased machinery and done the work for $19 a cubic yard. The average cost per yard, including labor, materials, repairs, and transfer of machinery, but not including cost of machinery ($11,100), was $14.36. For the work now proposed new machinery would have to be purchased or the work done by contract, and it has therefore been deemed advisable to estimate the cost at $25 a cubic yard.

The estimate will then be as follows:

1,600 cubic yards rock excavation, at $25	$40,000 00
Contingencies, 10 per cent	4,000 00
	44,000 00

There are other rocks near the left bank of the river, and about 1,600 feet below that at the lock, which would be somewhat in the way of boats towed along the bank. They are, however, inside the harbor line proposed by the board of survey in their report upon the improvement of the harbors of Washington and Georgetown, December 12, 1872, and it would be more economical to build a tow-path along this line than to attempt the removal of the rocks. No estimate for the work has therefore been made.

Very respectfully, your obedient servant,
S. T. ABERT,
United States Civil Engineer.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

G 2.

IMPROVEMENT OF ACCOTINK CREEK, VIRGINIA.

No work has been done upon this improvement since April, 1873, when a channel was completed from the town of Accotink to a point in Accotink Bay, 1½ miles below the town.

A part of the channel was 25 feet wide and 4 feet deep, and the remainder 40 feet wide and 2½ to 3 feet deep. At the date of the last annual report this channel had filled in so that the depth was only from 2½ to 3 feet at low-water.

For this reason the amount of trade is small, being about the same as reported last year. No examination has been made during the year, as no funds have been available. An appropriation of $5,000 was made June 10, 1872, which was expended under the direction of Colonel Craighill.

The amount needed to complete the work according to the original estimate is $14,000. For a channel 100 feet wide and 6 feet deep in the bay, and 50 feet wide and 6 feet deep in the upper part of the creek, $22,000 would be required.

Accotink is in the collection-district of Alexandria, which is the nearest port of entry.

G 3.

IMPROVEMENT OF OCCOQUAN RIVER, VIRGINIA.

An appropriation of $10,000 was made in the river and harbor act approved June 18, 1878, for the completion of this improvement. It is proposed to expend this amount in the excavation of a channel at the mouth of the river, either in the old line or a new line more nearly in the direction of the tidal currents. The channel above the railroad bridge is reported in good condition, and the advisability of the construction of the dike proposed at this point will depend upon the depth which the river is found to have maintained at this point.

The original estimate was $18,000. Owing to the fact that the work has extended over several years, and to additional work which has been needed, the estimate for the entire work has been increased to $25,000. The following appropriations have been made:

March 3, 1873	$5,000 00
June 23, 1874	5,000 00
March 3, 1875	5,000 00
June 18, 1878	10,000 00

No further appropriations for this work are required.

Occoquan is in the collection-district of Alexandria, which is also the nearest port of entry.

The following statistics of the trade of the river have been furnished by Mr. J. T. Janney of Occoquan:

RECEIPTS.

12,691 bushels wheat, valued at	$17,493 88
11,746 bushels corn, valued at	1,259 10
Estimated amount of merchandise received by eight stores, valued at	30,000 00
	48,752 98

SHIPMENTS.

4,187 barrels flour, valued at	$27,215 00
10,000 bushels mill offal, valued at	2,000 00
30,000 pounds sumac, valued at	350 00
8,200 cords wood, valued at	26,600 00
Wharf and bridge piles, and lumber, valued at	10,000 00
200,000 hogshead-hoops, valued at	7,250 00
60,000 barrel-hoops, valued at	600 00
16,000 cedar posts, valued at	2,300 00
2,000 dozen eggs, valued at	250 00
	76,565 00

Money statement.

July 1, 1877, amount available	$202 01	
Amount appropriated by act approved June 18, 1878	10,000 00	
		$10,202 01
July 1, 1878, amount expended during fiscal year		202 01
July 1, 1878, amount available		10,000 00

G 4.

IMPROVEMENT OF AQUIA CREEK, VIRGINIA.

The completion of this work was provided for by the appropriation of $5,000 in the act of June 18, 1878. A channel had been excavated through the shoalest part of the creek above the railroad-bridge, the last work having been completed in September, 1875, since which date no examination had been made for want of funds. As the present appropriation is explicitly stated in the act to be for "completing the improvement," the work will be conducted with this object in view.

It is therefore proposed to dredge a channel 5 feet deep, and of such width as the funds will permit, through the portions of the creek above and below the railroad-bridge still needing improvement.

Appropriations have been made as follows:

June 10, 1872	$1,500 00
March 3, 1873	2,000 00
March 3, 1875	2,000 00
June 18, 1878	5,000 00

The estimate for the entire work was $20,000.

Aquia Creek is in the collection-district of Alexandria, which is the nearest port of entry.

Money statement.

Amount appropriated by act approved June 18, 1878	$5,000 00
July 1, 1878, amount available	5,000 00

G 5.

IMPROVEMENT OF NOMINI CREEK, VIRGINIA.

No work has been done on this improvement during the year, no appropriation having been made. The last dredging operations were suspended in September, 1876, the funds having been then exhausted. As stated in the last report, the channel should be still further widened and

deepened, to obviate the effects of high winds and cross currents which, owing to its exposed position, tend to fill it up. The present channel is not as wide as originally contemplated, and the passage of steamers through the unfinished cut causes the material to wash from the slopes into it, so that it will need to be deepened as well as widened to meet the wants of navigation.

For this work an appropriation of $10,000 is recommended.

The original estimate was $20,000. Owing to the deterioration of the channel, its exposed position, and the small appropriations made, it has been necessary to do more work than was originally estimated for, so that the total estimate as revised is $31,000.

The following amounts have been appropriated:

March 3, 1873	$10,000 00
June 23, 1874	6,000 00
March 3, 1875	5,000 00

An appropriation of $10,000 is now recommended, and it is important that it all should be appropriated at one time.

The trade has materially increased since this improvement has been commenced. Two steamboats now pass regularly through the channel, each making semi-weekly trips to Washington. Increased facilities for transportation have been extended to the large section of country of which this stream is the natural outlet, and the beneficial results of the improvement have been very marked.

Money statement.

Amount (estimated) required for completion of existing project	$10,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.	10,000 00

G 6.

IMPROVEMENT OF RAPPAHANNOCK RIVER, VIRGINIA.

At the date of the last annual report dredging operations were in progress at Fredericksburg Bar. These were completed July 26, 1877, the total amount of excavation being 22,828 cubic yards; 353½ feet of dike were also built. A channel 50 feet wide and 9 feet deep at low-water was dredged from the steamboat wharf at Fredericksburg to Deep Run, at the lower end of the bar.

The surveys of the last three years show that new deposits of sand on this bar take place at about the same localities each year. It is probable that this tendency can be to a great extent corrected by the dikes which it is proposed to construct during the present season, and which will also serve as places of deposit for the dredged material.

The dredging already executed has resulted in a general improvement of the lower part of the bar as compared with its condition in 1873. The difficulties of accomplishing permanent results on this part of the river have been due to the fact that it is nearly at the head of tide-water, and also to the action of freshets causing a deposit of sand brought down from the river valley above. For this reason an annual appropriation for dredging this bar has been recommended.

As comparatively permanent results seem likely to be secured on at least the greater part of Fredericksburg Bar by the operations proposed, the improvement of the river below Fredericksburg can now be resumed with advantage.

The work remaining to be done in order to complete the present plan of improvement is as follows:

Spottswood Bar, widening and deepening channel.
Castle's Ferry Bar, dredging channel.
Farleyvale Reach, dredging channel.
Nanzatico Reach, dredging and dike.
Naylor's Hole, dredging and dike.

These obstructions have been fully described in former reports. The estimated cost of a channel 100 feet wide and 10 feet deep at low-water through the bars and shoals between Tappahannock and Fredericksburg is $50,000, and it is recommended that $30,000 be appropriated for the next fiscal year.

An appropriation of $13,500 was made June 18, 1878, for the continuation of the work. Two dikes will be built during the present season, one extending from the lower wharf down the river on the right bank and the other on the left bank in the lower part of Fredericksburg Reach.

The balance of this appropriation will be applied to dredging at points where the channel has shoaled.

Appropriations have been made as follows:

March 3, 1871	$15,000 00
June 10, 1872	15,000 00
March 3, 1873	15,000 00
June 23, 1874	7,000 00
March 3, 1875	5,000 00
August 14, 1876	10,000 00
June 18, 1878	13,500 00

Money statement.

July 1, 1877, amount available, not including $631.62 due on contract	$2,287 39	
Amount appropriated by act approved June 18, 1878	13,500 00	
		$15,787 39
July 1, 1878, amount expended during fiscal year, not including $631.62 due on contracts and also paid		2,287 39
July 1, 1878, amount available		13,500 00
Amount (estimated) required for completion of existing project		50,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880		30,000 00

G 7.

IMPROVEMENT OF LEONARDTOWN HARBOR, MARYLAND.

The act of June 18, 1878, making appropriations for the improvement of rivers and harbors contained a provision for the commencement of the improvement of the harbor of Leonardtown, in Breton Bay, Maryland, by an appropriation of $5,000. A survey of this harbor was made in December, 1874, under the direction of Maj. William P. Craighill, Corps of Engineers, and a report upon the same, with an estimate of the cost of improvement, was made by him June 19, 1875. (Report of Chief of Engineers for 1875, Part II, page 108.)

Leonardtown is situated at the head of navigation of Breton Bay, and is the county seat of Saint Mary's County, Maryland. It is a popular place of summer resort, and is in the midst of a very productive country, whose trade, in the absence of any other means of communication, finds

its outlet by shipment from Leonardtown and the bay. There are two lines of steamers connecting Leonardtown with Washington, D. C., and one with Baltimore, each making two trips a week.

The obstruction to navigation consists in an insufficient depth of water between the wharf at the foot of the main street of Leonardtown and a point in the bay one-half mile below. But five feet of water can be carried to this wharf, owing to this deposit, which is soft mud and easily dredged.

Estimates were submitted in the report above referred to, for several channels of varying widths and depths. In view of the increased trade, and the need of a considerable width of channel for turning of steamers, as well as the soft nature of the bottom, I recommended, in submitting a project for this work, that the largest channel, 150 feet wide and 9 feet deep at low-water, be taken as the basis of operations. This recommendation having been approved by the Chief of Engineers, the appropriation of $5,000, made June 18, 1878, will be applied to dredging so much of this channel as the funds will permit.

The balance required to complete the improvement according to the original estimate is $25,000, and it is recommended that at least $15,000 be appropriated for the year ending June 30, 1880, in order that the work may be done at more reasonable rates.

Money statement.

Amount appropriated by act approved June 18, 1878	$5,000 00
July 1, 1878, amount available	5,000 00
Amount (estimated) required for completion of existing project	25,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880	15,000 00

G 8.

IMPROVEMENT OF HAMPTON RIVER, VIRGINIA.

An appropriation of $10,000 was made in the act approved June 18, 1878, for this improvement. The obstruction to navigation is a bar which is found at the mouth of the river where it enters Hampton Roads, about 2 miles from Fortress Monroe. A survey of the bar was made in 1874, and a report upon the same with an estimate of the cost of its improvement was made February 22, 1875. The least depth of water over the bar is 4½ feet. It is proposed during the present season to dredge a channel from 8 to 9 feet deep at low-water, with such width as the funds may permit. The bar is formed largely of sand. The statistics collected at the time the survey was made show that Hampton has a thriving trade, the river being the outlet for the trade of three counties. I respectfully refer to the report above mentioned for full statistics of the trade and details of the results of the survey. (Report of Chief of Engineers, 1875, Part II, page 152.)

The original estimate of the cost of the improvement was $16,000. The amount appropriated June 18, 1878, was $10,000, leaving $6,000 as the amount required for the completion of the improvement.

Money statement.

Amount appropriated by act approved June 18, 1878	$10,000 00
July 1, 1878, amount available	10,000 00
Amount (estimated) required for completion of existing project	6,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880	6,000 00

G 9.

IMPROVEMENT OF ELIZABETH RIVER, VIRGINIA.

The work of the last year under the appropriation of August 14, 1876, has been the excavation of a cut-off near the lock of the Albemarle and Chesapeake Canal, and the widening of the gap about three-fourths of a mile below, which was commenced August 13, 1877. The cut-off was 50 feet in average width; its depth was 11 to 12 feet below the adjacent marsh, or 7 to 8 feet below low-water. The material found was largely sand, with some marsh soil and stumps; 12,560 cubic yards of material were excavated, measured in bank. The cut-off effected the result intended, which was to decrease the velocity of the tidal current at the lock so as to enable vessels to enter it safely.

The gap was widened 20 feet, with a slope on its left bank, and the passage of steamers and long tows has thereby been greatly facilitated. Five thousand one hundred and seventy-nine cubic yards of material were removed. The work was completed November 13, 1877.

The work remaining to be done, for which the appropriation of June 18, 1878, was asked, is deepening the approaches to the gap, and the excavation of a channel through a bar below the same.

The original estimate for this river was $25,000, but owing to the increase of traffic and navigation a more liberal system of improvement than that at first proposed has been found necessary, increasing the total estimate to $40,000. This amount has been appropriated and no further expenditure is required at the present time.

Appropriations have been made as follows:

March 3, 1873	$15,000 00
June 23, 1874	10,000 00
March 3, 1875	5,000 00
August 14, 1876	5,000 00
June 18, 1878	5,000 00

Elizabeth River is in the collection-district of Norfolk.

The principal shipments to Norfolk during the year ending September 30, 1877, were:

Bales of cotton	63,475
Barrels of fish	14,175
Barrels of naval stores	16,259
Bushels potatoes	28,355
Barrels corn	591,724
Railroad-ties	32,521
Laths	1,067,500
Feet of lumber	31,589,516
Shingles	31,822,525
Staves	672,739
Passengers	1,840

Number and class of vessels passed through Elizabeth River for the year ending September 30, 1877, were:

Steamers	2,376
Schooners	1,626
Sloops	508
Barges	344
Lighters	587
Boats	277
Rafts	123
Total	5,841

Money statement.

July 1, 1877, amount available	$4,989 89	
Amount appropriated by act approved June 18, 1878	5,000 00	
		$9,989 89
July 1, 1878, amount expended during fiscal year		4,721 94
July 1, 1878, amount available		5,267 95

G 10.

IMPROVEMENT OF NORFOLK HARBOR, VIRGINIA.

During the past fiscal year a channel has been dredged through the bar at the mouth of the eastern branch of Elizabeth River, in the most important part of the harbor, under the appropriation of $35,000 made August 14, 1876, this being the first appropriation made for this improvement.

The contract for this work was awarded to Mr. Sidney F. Shelbourne, of New London, Conn., the lowest bidder. The date fixed for the commencement of the work was September 15, but Mr. Shelbourne asked an extension of time to repair his dredges, which was granted.

Messrs. George C. Fobes & Co., of Baltimore, Md., submitted a power of attorney from Mr. Shelbourne for the execution of this work, and by authority of the Chief of Engineers the work was done by them under this power.

Work was commenced October 15, 1877, with one large "clam-shell" dredge, and continued through the entire winter, with remarkably favorable weather, until April 3, 1878, when the channel was completed as far as the funds allowed, having a depth of from 20 to 22 feet at low-water, and an average width of 530 feet. The material found was a soft blue mud. It was deposited on Craney Island Flats, at a distance of 6¼ miles. Three tugs were used, two for towing, and one as a tender. The total amount of dredging was 284,898 cubic yards, and the daily average, including time lost for repairs, &c., 1,938 cubic yards, or, for actual dredging time, 2,766 cubic yards. The channel thus excavated has proved very beneficial to the commerce of the port, enabling vessels of deep draught to pass to any part of the harbor. For the completion of this particular channel, and the removal of wrecks near it, the sum of $25,000 was recommended in the last annual report. Reference was also made in that report to the proposed plan for the general improvement of the harbor and its approaches, under consideration by the United States Advisory Board to the Harbor Commissioners of Norfolk.

The final recommendations of the board have since been made, and were referred to me by your letter of May 15. An estimate for the entire improvement was submitted in my report of May 16 (Senate Ex. Doc. No. 88, Forty-fifth Congress, second session), and is also given below.

The plan of improvement is as follows: In the immediate harbor it is proposed, in addition to the work already executed, to deepen and widen the channel at the mouth of the Southern Branch, and along the Berkley and Portsmouth Flats. For the approaches to the harbor it is recommended that a channel 500 feet wide and 25 feet deep at low-water be excavated at Sewall's Point near Hampton Roads, and opposite the mouth of the Western Branch (of Elizabeth River), where bars have formed.

The following is the estimated cost of the proposed improvement, in addition to the work already executed:

	ESTIMATE.
In the immediate harbor	$112,200
Between Norfolk and Hampton Roads	205,755
Total	317,955

The execution of this improvement will afford access to Norfolk Harbor for the largest class of vessels engaged in commerce and give increased harbor accommodations for the trade of the port. The export values of Norfolk shipments increased six-fold from 1873 to 1876, and are now from $6,000,000 to $7,000,000 a year.

In my report of 1875 upon this improvement it was stated that—

The harbor of Norfolk, taken in connection with the excellent anchorage in Hampton Roads, has justly been regarded as one of the finest on the continent. The depth of its channels, security of its anchorage, capacity, freedom from ice, facility of entrance and departure, combined with a central geographical position at the mouth of the largest bay in the country, confer on it an unquestionable superiority.

There are steamboat and steamship lines connecting this port with the sounds of North Carolina, and its extensive system of inland transportation, the cities of Richmond, Baltimore, Providence, New York, and Boston, and two railroads connecting Norfolk with the South and Southwest.

The principal shipments are cotton, oysters, lumber, early fruits, and vegetables.

The improvement projected would greatly increase the value and importance of the navy-yard at Portsmouth by rendering it accessible to the largest class of vessels at all stages of the tide.

The act of June 18, 1878, appropriated $50,000 for the continuation of this improvement. It is proposed to apply this sum to the completion of the channel at the mouth of the Eastern Branch, and the commencement of the work contemplated in the above estimate for the harbor and its approaches. At least $100,000 should be appropriated each year, in order that each channel may be completed during the season in which it is commenced, and the work thereby be most advantageously and economically executed.

The following statistics exhibit fully the importance of the trade of Norfolk.

Foreign-bound shipping.

Year.	Number of bottoms.	Tonnage.
1873	71	30,613
1874	96	51,139
1875	119	53,683
1876	94	65,504
1877	113	62,093
Total	493	263,032

Coastwise clearances.

Year.	Tonnage.	Crew.	Number of bottoms.
1873	1,021,376	29,368	1,072
1874	1,119,029	30,506	1,183
1875	968,271	25,865	1,022
1876	1,104,747	28,800	1,072
1877	973,898	24,581	941
Total	5,187,321	139,120	5,290

STATEMENT OF EXPORT VALUES.

1873	$1,267,769
1874	3,906,318
1875	6,243,972
1876	7,825,112
1877	6,278,933
Total	25,522,904

The following is a statement of exports, &c., of this port for fiscal year ending June 30, 1878:

Value of exports—cotton, staves, grain, and miscellaneous articles, $8,709,085.

Entrances, coastwise	996
Entrances, foreign	46
Clearances, coastwise	957
Clearances, foreign	116
Total	2,115

The following appropriations have been made for this work:

August 14, 1876	$35,000 00
June 18, 1878	50,000 00

Money statement.

July 1, 1877, amount available	$34,710 85	
Amount appropriated by act approved June 18, 1878	50,000 00	
		$84,710 85
July 1, 1878, amount expended during fiscal year		31,405 07
July 1, 1878, amount available		53,305 78
Amount (estimated) required for completion of existing project		293,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880		100,000 00

LETTER OF CHAIRMAN OF UNITED STATES ADVISORY BOARD TO HARBOR COMMISSIONERS OF NORFOLK AND PORTSMOUTH.

WASHINGTON, D. C., *May* 6, 1878.

SIR: Having completed our duties in regard to the establishment of the port-warden lines of the *occupied* portions of the harbor of Norfolk, we have had under consideration a plan for the general improvement of the harbor and its approaches. We find that from various causes there has been of late years a decrease in the width and also in the depth of the channel, and that the harbor itself has been gradually shoaling. These changes are due to the deflection of the natural forces of the current in some sections, owing to the undue extension of certain points, to the erection of bridges and obstructions sunk in the channel-way during the late war, and for the want of proper police regulations heretofore to prevent the harbor being used indiscriminately as a dumping-ground for all kinds of *débris* from vessels at anchor in the harbor or secured to its wharves. These are some of the principal causes which, combined, have impaired to some degree one of the finest natural harbors in the country.

To restore the integrity of the harbor, and to make it subservient to the increasing wants of commerce, will require extensive dredging, involving liberal expenditures.

The general government has here the most important naval station south of New York, and upon which millions of dollars have already been

expended. Located upon a site selected by the fathers of the Navy, by reason of its great natural advantages, in close proximity to the pitch, tar, turpentine, and lumber and ship's timber regions of the South, and to the coal and iron districts of both the Virginias, admirably protected by its remoteness from the sea from any hostile demonstrations from without, with a climate where labor yields its best returns, and where skilled labor abounds, and accessible at all seasons of the year by its freedom from ice of sufficient thickness to obstruct its free navigation, its claims to favorable consideration assert themselves, and require no argument to make them manifest. The importance of the harbor of Norfolk cannot be overestimated either in a national or commercial regard.

Left helpless and prostrate from the effects of the war, with its commerce, its industries, and its wealth almost annihilated, Norfolk is to-day one of the principal cotton marts of the world, and with its railroad connections extending landward in every direction, its unrivaled situation, its splendid lines of steamers to Europe, New York, Boston, Providence, Baltimore, and Richmond, and its steam connections with Philadelphia and coastwise in almost every direction, together with an inland communication by means of the Chesapeake and Albemarle Canal almost continuous to the Gulf of Mexico, all combine to make it a most important point for the interchange of the manufactures and products of the North and of the Old World with the virgin yield of the South and West.

In our recommendation for the improvement of the harbor and its approaches, we have not merely considered the necessities of the present, important as they are, but also have endeavored to submit a plan which will meet the requirements of the future, when the whole country, which is now but in a chrysalis condition, shall be fairly peopled, and the fruitful territories of the South and the West measurably developed.

I have the honor to submit in this connection a copy of the third report of our advisory board in duplicate.

Very respctfully,

T. H. STEVENS,
Commodore, U. S. N., Chairman U. S. Advisory Board to Harbor Commissioners of Norfolk and Portsmouth.

Hon. GEO. W. MCCRARY,
Secretary of War.

REPORT OF THE UNITED STATES ADVISORY BOARD.

WASHINGTON, D. C., *May* 6, 1878.

DEAR SIR: In our report of January, 1877, we recommended the deepening below the mouth of the Southern Branch and upon the margin of the Portsmouth Flats as projects of improvement to be undertaken subsequent to the removal of shallow ground in the approaches to the harbor, but postponed further remarks upon this last-named project with the hope that our inquiries into the history of those outer shoals would assist us in forming a proper judgment as to the width of channel that could be used and maintained most economically. We have not been as successful in these inquiries as we had hoped, but we have decided to make the following recommendations, viz:

1st. That the outer bar opposite and above Sewall's Point should be deepened to 25 feet at mean low-water for a distance of 8,400 feet and a width of 500 feet, including slopes of repose. To accomplish this the

gross amount of dredging required would be 400,000 cubic yards, with an average cut of something less than 1 yard and a maximum cut of $1\frac{1}{8}$ yards.

2d. That the bar opposite the mouth of Western Branch should be deepened to 25 feet at mean low-water for a distance of 4,800 feet and a width of 500 feet, including slopes of repose. The dredging would here amount to 300,000 cubic yards, the average cut being $1\frac{1}{10}$ yards and the maximum cut $1\frac{8}{10}$ yards.

Very respectfully,

T. H. STEVENS,
Commodore, U. S. N., Chairman of U. S. Advisory Board to Harbor Commissioners of Norfolk and Portsmouth,
CHAS. B. PHILLIPS,
Captain of Engineers,
HENRY MITCHELL,
U. S. Coast Survey,
Members of U. S. Advisory Board, &c., &c., &c.
CHARLES REID, Esq.,
President State Harbor Commission of Norfolk and Portsmouth, Va.

REPORT OF MR. S. T. ABERT, UNITED STATES CIVIL ENGINEER.

UNITED STATES ENGINEER OFFICE,
Washington, D. C., May 16, 1878.

GENERAL: I have the honor to acknowledge the receipt of your letter of the 15th instant, referring the third report of United States Advisory Board to the Harbor Commissioners of Norfolk and Portsmouth, relative to a plan for the improvement of the harbor of Norfolk, for report and estimate, in connection with the improvement now in progress, and would respectfully submit the following report:

The Advisory Board have submitted three reports in relation to the establishment of port-warden lines within the harbor of Norfolk and to the improvement of the harbor and the channel to Hampton Roads.

The first two reports were referred to me by your letter of March 17, 1877, and were returned with my report June 5, 1877. These reports relate to the port-warden lines and the dredging required to make these lines available for the purposes of trade. This third and final report relates wholly to the dredging required to obtain a channel 500 feet wide and 25 feet deep at low-water from Hampton Roads to the city of Norfolk and to the Portsmouth navy-yard.

The consideration of the port-warden lines does not come within the purview of this communication, and may safely be left with the intelligent officers who compose the board and with the harbor commissioners, with whom remains the power to accept or to modify or reject the lines proposed, and to establish regulations for the government of the riparian owners in erecting docks and wharves.

This right can be exercised so long as the docks, wharves, and pier-heads do not obstruct the public highway.

My comments will therefore be confined to the improvements recommended, which differ slightly from those mentioned in the Reports of the Chief of Engineers. In Part II, page 147, of the Report for 1875, it is stated in regard to that part of the improvement along the Portsmouth Flats, that "it would be necessary to rectify the wharf-front of the city of

Portsmouth, commencing at the northern point and extending 1,200 feet above, pushing the entire front back until at the northern point it will be about 300 feet in the rear of its present position. The line should then be continued by dredging from the point of the wharf to the 25-foot curve of depth, turning on a gentle curvature to the left hand. Between this line and the channel the material should be dredged to a depth of 20 feet. These operations involve an interference with riparian rights and require a large amount of dredging. I regard them, however, as essential parts of any plan for the correction of all the forces which co-operate to form the bar."

The Advisory Board propose to push back the wharf-front 110 feet instead of 300 feet, and to dredge to 25 feet instead of 20, increasing the depth, but reducing the width of this part of the channel. Neither of these propositions for removing the wharf-front can be carried out without the consent of the riparian owners. I have been credibly informed, however, that their consent can be obtained, but no estimate can be made of this part of the work without further examination and consultation.

In the Report of the Chief of Engineers for 1877, Part I, page 364, it is also stated that "In order to carry 25 feet from Hampton Roads up to the city of Norfolk, it will be necessary to dredge the channel between the Hospital light and Sewall's Point, so as to give a width of 400 feet and a low-water depth of 25 feet."

The Advisory Board recommend that the channel should be made 500 feet wide, including slopes of repose.

In the following estimate the dimensions proposed by the board have been adopted, and the work already done in removing the bar at the mouth of the Eastern Branch, as well as the amount asked in the last annual report to complete the removal, have been deducted from the total.

I would call attention to the fact that in order to give a clear depth of 25 feet at low-water it will be necessary to dredge to a depth of 26 feet, and that the quantity measured *in situ* must be increased at least 15 per cent., in order to make it equivalent to the same quantity measured in the dumping-scows. I have adopted this equivalence as the result of practical observation in the recent dredging within the harbor of Norfolk. I would further remark that the material to be dredged has been assumed to be of the same character as that removed from the Eastern Branch bar.

The estimate is given under two heads, viz: within the harbor of Norfolk, and from Hampton Roads to Norfolk Harbor.

ESTIMATE.

(1.) *Within the harbor of Norfolk:*

The dredging is the amount recommended by the board, and extends to the port-warden lines.

680,000 cubic yards dredging, at 15c	$102,000
Contingencies, 10 per cent	10,200
Total	112,200

(2.) *From Hampton Roads to Norfolk and the Portsmouth navy-yard:*

Channel 500 feet wide, 26 feet deep, at low-water. The approximate amount of dredging would be—

	Cubic yards.
At Sewall's Point	617,000
Opposite Western Branch	552,000
Shoal at buoy 12	78,000
Total dredging	1,247,000

The estimated cost will be as follows:

1,247,000 cubic yards dredging, at 15c	$187,050
Contingencies, 10 per cent	18,705
Total	205,755

SUMMARY.

(1.) In the harbor proper	$112,200
(2.) Between Norfolk and Hampton Roads	205,755
Total estimate	317,955

The general location of the proposed channel is shown on the accompanying tracing.

When this work is completed, there will be a 25-feet channel at low-water from Hampton Roads to the city of Norfolk and Portsmouth navy-yard, and Norfolk Harbor will become a shipping port of the first class.

An opinion regarding the causes of the deterioration of the channel could hardly be expressed without further examination.

The commercial importance of the harbor of Norfolk is too well known to need further commendation.

The letter of Commodore Stevens, with the report of the Advisory Board, is herewith respectfully returned.

Very respectfully, your obedient servant,

S. T. ABERT,
United States Civil Engineer.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

G 11.

IMPROVEMENT OF CHICKAHOMINY RIVER, VIRGINIA.

The river and harbor act approved June 18, 1878, contained an appropriation of $5,000 for the improvement of this river. An examination of it had been made under the provision of the act of June 23, 1874, and a report submitted May 24, 1875, to which I respectfully refer (Report of Chief of Engineers for 1875, Part II, page 170), for detailed information as to the character of the river, its trade, and a statement of the obstructions which prevent its free navigation.

The most important work, and that which it is first proposed to undertake, is deepening a channel through Binn's Bar and the bar at Windsor Shades. After this is done, the snags and logs which obstruct the navigation above these points can be removed.

The original estimate was about $10,000, but as no survey has been made, it may be necessary to increase this somewhat, if additional work is needed. At least $5,000 would be required for the continuation of the work.

Money statement.

Amount appropriated by act approved June 18, 1878	$5,000 00
July 1, 1878, amount available	5,000 00
Amount (estimated) required for completion of existing project	5,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.	5,000 00

G 12.

IMPROVEMENT OF BLACKWATER RIVER, VIRGINIA.

The portion of this river between Franklin on the Seaboard and Roanoke Railroad and the Chowan (13 miles below Franklin), forms a part of the important line of navigation between Norfolk and the western part of Albemarle Sound. There are three steamers which ply on the river, the mail-steamer making tri-weekly trips between Franklin and Edenton and Plymouth, N. C.

The Blackwater flows largely through cypress swamps, and varies in width from 100 to 275 feet, with a depth of from 8 to 38 feet. A survey of the river was made in accordance with the act of June 23, 1874, and a report upon the same made March 3, 1875. (Report of Chief of Engineers for 1875, Part II, page 161.)

The obstructions to navigation consist of snags and trees, and a sharp bend called George's Bend, where it is proposed to widen the channel by cutting off one of the points of the bend. The original estimate for the improvement was $15,000.

The act approved June 18, 1878, appropriated $5,000 for the work, so that $10,000 still remains to be appropriated. This appropriation of $5,000, now available, will be applied to the removal of snags, logs, and other obstructions, being insufficient for the commencement of dredging operations. It is proposed to execute the work by hired labor, this having been found the most economical and satisfactory method of conducting snagging operations.

Money statement.

Amount appropriated by act approved June 18, 1878	$5,000 00
July 1, 1878, amount available	5,000 00
Amount (estimated) required for completion of existing project	10,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.	10,000 00

G 13.

IMPROVEMENT OF FRENCH BROAD RIVER, NORTH CAROLINA.

A survey of this river was about to be commenced when the last annual reports were made. This survey was commenced in July and completed during September, 1877. The maps were then plotted and estimates for the improvement made.

The results of the survey were submitted in a special report dated February 12, 1878 (appended hereto), and to which reference is respectfully made for full details as to the character of the river, and the feasible plans for its improvement.

It was found that pending the preparation of the maps and report, a considerable amount of work in removing snags, logs, driftwood, &c., could advantageously be done and would be applicable to any plan of improvement which might be adopted. A preliminary report was submitted, and authority asked and granted to commence the work by hired labor, as specific estimates could not be prepared, and as this was the only practicable method of executing it in that locality. Material and tools for the work were purchased and operations commenced in October. A derrick or snag-boat and scows were built and snags and drift-logs re-

ved from a part of the river. Two fish-traps have been removed and
) cubic yards of rock quarried near Davidson's River for the construc-
n of wing-dams. Work was suspended for the winter on Decem-
· 15.

The funds available for continuing the improvement in the spring of
'8 were not sufficient to allow any work except the snagging to be
lertaken. The derrick-boats built during the fall were fitted up for
s work, and active operations commenced in April.

Only such snags have been removed as were in the main channel of
· river. The snagging will probably be completed early in July.

The continuation of this improvement was provided for by an appro-
ation of $15,000 in the river and harbor act of June 18, 1878, and the
nstruction of wing-dams and excavation of rock and gravel at the
als will be at once commenced. This method of improvement is the
st expensive of the plans suggested and will undoubtedly meet the
uirements of trade for many years.

The estimated cost of the entire improvement by wing-dams is $45,500.
is estimate did not include the removal of snags which was in progress
the time, and which, together with the cost of surveys, &c., was pro-
led for by the first appropriation.

The following appropriations have been made:

gust 14, 1876	$10,000 00
e 18, 1878	15,000 00

The amount remaining to be appropriated is $30,000.

The accompanying table shows the changes in the water surface dur-
: the year. The observations were taken on ganges established at
ilson's Bridge, Shuford's Bridge, and Big Buck Shoal.

Money statement.

y 1, 1877, amount available	$10,000 00	
ount appropriated by act approved June 18, 1878	15,000 00	
		$25,000 00
y 1, 1878, amount expended during fiscal year		7,162 08
y 1, 1879, amount available		17,837 92
ount estimated required for completion of existing project		30,000 00
ount that can be profitably expended in fiscal year ending June 30, 1880		20,000 00

Table showing the average daily stage of the French Broad River at Wilson's Bridge, Shuford's Bridge, and Buck Shoal, during the year ending June 30, 1878.

Days of month.	August.			September.			October.			November.			December.			January.			February.			March.			April.			May.			June.		
	Wilson's Bridge.	Shuford's Bridge.	Buck Shoal.	Wilson's Bridge.	Shuford's Bridge.	Buck Shoal.	Wilson's Bridge.	Shuford's Bridge.	Buck Shoal.	Wilson's Bridge.	Shuford's Bridge.	Buck Shoal.	Wilson's Bridge.	Shuford's Bridge.	Buck Shoal.	Wilson's Bridge.	Shuford's Bridge.	Buck Shoal.	Wilson's Bridge.	Shuford's Bridge.	Buck Shoal.	Wilson's Bridge.	Shuford's Bridge.	Buck Shoal.	Wilson's Bridge.	Shuford's Bridge.	Buck Shoal.	Wilson's Bridge.	Shuford's Bridge.	Buck Shoal.	Wilson's Bridge.	Shuford's Bridge.	Buck Shoal.
1	0.3	0.5	.....	0.1	0.2	0.3	—0.1	0.2	0.3	0.2	0.8	0.8	1.3	2.7	1.7	2.6	4.3	3.7	1.8	3.3	1.4	2.6	4.1	1.7	1.5	2.4	0.7	1.3	2.4	0.7	0.5	1.1	0.2
2	0.1	0.6	.....	0.1	0.2	0.2	0.1	0.2	0.2	3.5	4.1	2.4	1.2	2.5	1.0	2.1	3.7	2.9	1.6	2.9	1.4	2.7	4.2	1.7	1.4	2.3	0.6	1.3	2.3	0.6	0.4	1.0	0.2
3	0.1	0.7	.....	0.1	0.5	0.2	0.2	0.9	0.3	2.1	3.2	3.0	1.0	2.3	0.6	1.9	3.6	1.9	1.6	2.8	1.5	5.4	7.3	3.2	1.3	2.4	0.5	1.2	2.2	0.5	0.4	1.0	0.2
4	0.1	0.5	.....	0.1	0.8	0.1	3.1	4.6	3.6	1.1	1.1	2.2	1.1	2.3	0.3	2.0	3.5	1.2	1.6	2.8	1.4	3.5	5.3	2.8	2.0	2.9	1.2	2.0	3.0	1.0	0.6	1.2	0.5
5	0.1	0.5	.....	0.1	1.0	0.2	1.3	2.3	3.2	1.0	1.3	1.9	4.8	6.1	1.1	1.7	3.4	0.8	1.6	2.8	1.3	2.9	4.5	2.2	1.6	2.5	1.0	2.7	4.4	2.1	0.6	1.2	0.4
6	0.1	0.8	.....	0.2	1.0	0.6	0.2	1.3	1.9	1.0	2.0	1.6	4.5	8.0	1.7	1.6	2.7	0.5	1.6	2.7	1.3	2.6	4.1	1.8	1.4	2.4	0.8	1.8	3.0	1.3	0.4	1.1	0.4
7	0.1	0.5	.....	0.1	0.6	0.5	0.1	1.0	1.3	0.8	1.5	1.4	3.0	4.4	1.6	1.5	2.6	1.3	2.1	4.3	1.7	2.4	3.7	1.6	1.3	2.4	0.7	1.5	2.6	1.0	0.4	0.9	0.3
8	0.1	0.5	.....	0.1	0.2	0.4	2.7	3.7	3.6	5.2	5.4	3.2	2.4	3.8	1.3	1.4	2.6	1.1	8.4	11.6	6.7	2.3	3.5	1.5	1.3	2.3	0.7	1.4	2.4	0.8	1.0	1.4	0.6
9	0.1	0.5	.....	0.1	0.2	0.2	1.4	3.2	2.8	5.0	(*)	6.1	1.7	3.7	1.1	1.9	3.9	1.5	6.2	10.4	7.5	2.1	3.4	1.4	4.2	4.3	1.4	1.3	2.2	0.7	0.6	1.2	0.5
10	0.1	0.5	0.4	0.2	0.5	0.4	0.7	1.9	1.3	2.4	4.4	5.2	1.6	3.3	0.7	5.3	8.1	5.0	4.2	7.7	6.2	2.3	3.4	1.4	4.5	7.2	3.2	1.2	2.2	0.6	0.5	1.0	0.4
11	0.1	0.6	0.3	0.5	0.8	1.4	0.5	1.4	1.2	1.7	3.2	3.5	1.5	2.6	0.5	3.3	5.5	4.4	3.3	5.3	4.0	3.0	4.6	1.7	3.0	4.9	2.3	1.1	2.0	0.5	0.4	0.8	0.4
12	0.1	0.6	0.3	0.1	1.0	1.1	0.3	1.1	1.2	1.3	2.6	2.5	1.5	2.5	0.4	2.6	4.4	3.1	2.8	4.4	2.3	3.4	6.0	2.5	2.3	3.3	1.7	1.0	2.0	0.4	0.4	0.7	0.4
13	0.2	0.5	0.5	0.1	1.0	0.8	0.3	1.0	1.1	1.1	2.1	2.0	1.3	2.4	0.3	4.3	4.2	2.7	2.6	4.1	1.5	6.1	8.7	4.3	2.0	3.3	1.4	1.0	2.0	0.4	0.5	0.9	0.3
14	0.1	1.2	0.8	0.1	0.6	0.7	0.3	0.9	0.9	0.9	2.2	1.5	1.2	2.3	0.2	4.0	5.9	3.9	2.5	3.9	1.2	3.2	5.7	3.2	1.8	3.2	1.0	1.2	2.5	0.7	0.4	0.9	0.3
15	0.1	0.8	0.6	0.1	0.4	0.6	0.2	0.8	0.8	0.9	1.9	1.3	1.2	2.3	0.1	3.3	5.0	3.2	2.3	3.8	1.1	3.1	4.7	2.6	1.8	3.0	0.8	1.1	2.3	0.6	0.3	0.8	0.2
16	0.1	0.6	0.4	0.1	0.4	0.5	0.1	0.7	0.8	0.8	1.7	1.0	1.1	2.1	0.3	2.9	4.2	5.2	2.2	3.7	0.9	2.7	4.2	2.0	2.0	3.4	1.2	1.0	2.1	0.5	0.3	0.8	0.2
17	0.1	0.5	0.3	0.1	0.3	0.5	0.4	0.6	0.7	0.8	1.6	0.8	1.0	2.0	0.3	2.6	3.8	2.1	2.1	3.4	0.8	2.5	4.0	1.7	1.6	2.7	1.0	0.9	1.9	0.4	0.3	0.8	0.2
18	0.1	0.5	0.3	0.1	0.4	0.5	0.1	0.6	6.6	0.7	1.5	0.5	0.9	1.9	0.2	2.2	3.5	1.8	2.3	3.6	0.8	2.3	3.8	1.6	1.5	2.6	0.7	0.8	1.8	0.4	0.5	1.0	0.1
19	0.1	0.5	0.3	0.4	1.1	0.5	0.1	0.5	0.5	0.6	1.4	0.3	0.9	1.9	0.1	2.0	3.5	1.6	2.1	3.5	0.9	2.1	3.4	1.4	1.4	2.6	0.6	1.1	2.0	0.7	0.4	1.0	0.3
20	0.1	0.2	0.3	1.5	2.8	1.3	1.0	1.3	0.7	0.6	1.3	0.3	0.8	1.8	0.1	3.8	4.0	2.2	2.0	3.1	1.2	2.0	3.2	1.3	1.4	2.8	0.5	1.2	2.0	0.8	0.3	0.8	0.2
21	0.1	0.2	0.3	0.8	1.2	2.2	1.7	3.8	2.5	2.3	3.7	0.2	0.8	1.7	0.0	3.3	4.8	2.9	5.9	7.5	3.1	2.0	3.1	1.2	1.3	2.6	0.8	0.9	2.1	0.7	0.3	0.8	0.2
22	0.1	0.1	0.2	0.2	0.7	1.5	0.7	1.7	1.8	7.7	(*)	5.7	0.9	1.7	0.1	2.6	4.2	2.3	11.9	13.9	8.2	1.9	3.0	1.1	1.3	2.4	0.7	0.9	2.0	0.6	0.3	0.7	0.3
23	1.2	2.0	0.1	0.1	0.7	1.0	0.4	1.2	1.4	4.9	(*)	6.4	1.3	2.2	0.2	2.3	3.8	2.0	8.0	13.4	6.8	1.8	2.9	1.0	1.2	2.3	0.6	0.8	1.9	0.5	0.2	0.7	0.2
24	0.2	1.1	1.2	0.1	0.6	0.7	0.4	1.0	1.2	4.6	(*)	6.6	3.1	4.4	0.8	2.1	3.4	1.6	4.2	9.8	5.3	1.7	2.9	1.0	3.2	2.4	0.6	0.8	1.7	0.4	0.2	0.6	0.2
25	0.1	0.5	0.6	0.1	0.6	0.6	0.3	1.0	1.1	3.6	6.0	5.4	6.3	7.9	1.1	2.0	3.2	1.5	3.4	5.4	3.5	1.6	2.6	0.9	3.7	5.5	3.2	0.7	1.6	0.4	0.2	0.6	0.1
26	0.1	0.4	0.4	0.1	0.5	0.5	0.3	1.0	1.0	3.3	5.8	4.2	4.7	8.4	2.2	1.8	3.1	1.4	3.4	5.1	2.7	1.5	2.6	0.8	2.2	3.8	2.1	0.6	1.6	0.3	0.1	0.5	0.1
27	0.1	0.2	0.3	—0.1	0.4	0.5	0.7	1.5	1.5	2.5	4.1	3.5	2.7	4.6	3.4	2.1	3.0	1.3	3.0	4.2	2.3	1.5	2.5	0.7	1.9	3.2	1.5	0.7	1.5	0.3	0.1	0.4	0.2
28	0.1	0.5	0.6	—0.2	0.4	0.4	0.3	1.4	1.3	1.9	3.5	2.9	2.2	3.8	2.7	2.2	3.8	2.9	2.8	4.3	1.9	2.2	2.9	0.7	1.6	3.0	1.2	0.6	1.4	0.3	0.1	0.4	0.1
29	0.1	0.8	0.8	—0.2	0.3	0.4	0.3	1.0	1.2	1.8	3.2	2.5	4.3	5.3	2.7	1.8	3.2	1.5	.....	.....	.....	2.0	3.3	1.2	1.5	3.6	1.0	0.5	1.4	0.2	0.1	0.7	0.5
30	0.1	0.5	0.6	—0.2	0.3	0.3	0.2	0.9	1.1	1.5	2.4	2.1	6.1	9.3	4.0	1.9	3.2	1.3	.....	.....	.....	1.7	2.6	0.9	1.4	2.6	0.8	0.5	1.3	0.2	0.1	0.8	0.4
31	0.1	0.5	0.4	.....	.....	.....	0.3	0.8	1.0	.....	.....	.....	3.7	5.7	4.7	2.1	3.2	1.3	.....	.....	.....	1.5	2.6	0.9	.....	.....	.....	0.5	1.2	0.3	.....	.....	.....

* Over gauge.

EXAMINATION OF FRENCH BROAD RIVER, NORTH CAROLINA AND TENNESSEE.

UNITED STATES ENGINEER OFFICE,
Washington, D. C., February 12, 1878.

GENERAL: Under date of August 27, 1877, I had the honor to submit a preliminary report of an instrumental examination of the French Broad River, North Carolina, from Brevard to the dividing line between Henderson and Buncombe Counties. A reconnaissance of this part of the river had been made in 1875 by Mr. McCalla, acting under the orders of Major McFarland; and in the following year an instrumental survey was made by the same engineer from the Henderson County line to Asheville, and a careful examination from Asheville to Leadvale, Tenn. The estimate of Mr. McCalla (revised) for improving the river:

From Brevard to the Henderson County line, 38.84 miles, was	$41,600
From thence to Asheville, 16.42 miles	83,400
Total for 55.26 miles	125,000

The object of the proposed improvement was to procure a low-water depth of 30 inches, by removing a portion of the rock, bowlders, and gravel from the bars, and also by contracting the water-way by means of lateral dams. The report of 1875 states, regarding the improvement, that—

> It seems to be quite useless to undertake it before the railroads are completed to Asheville; and then it would be useless unless extended from the Buncombe County line to Asheville.

During the past year, however, two railroads have been pushed with commendable zeal into the valley; one of these is an extension of the road from Spartanburg, S. C.; the other connects with the Piedmont Railroad at Salisbury, N. C. The former road has been graded to within 1½ miles of the river, near the Buncombe County line.

The act of Congress approved August 14, 1876, appropriated $10,000 for the commencement of the improvement, which was limited to the part of the river between Brevard and the Buncombe County line. Before this money could be expended an instrumental examination was necessary. The excellent reconnaissance of Mr. McCalla had demonstrated the practicability of an improvement. A more careful survey, however, was needed to obtain data for the preparation of definite plans and estimates. These plans could not be made without charts and a profile of the portion of the river to be improved; and without a knowledge of the depth, fall, and discharge of the river it could not be predicted to what extent a bar should be excavated or how much the width of the river should be contracted.

With your authority a survey party was accordingly organized and took the field in July, 1877. * * * When the survey reached the Buncombe County line an examination of the river was continued to Smith's Bridge.

DESCRIPTION OF THE RIVER FROM BREVARD TO ASHEVILLE.

The French Broad River rises in Transylvania County, North Carolina. Its springs lie about the foot of Cæsar's Head, a conspicuous spur of the Balsam Mountains, a majestic range which has an altitude of 6,278 feet above tide. The general course of the river, as far as Asheville, is northeast. The Blue Ridge bounds the valley upon the east, while the Balsam Range, with its lofty peak of Mount Pisgah, forms its western

boundary. The valley is thus closed at its head and upon two sides, but the general shape of the mountain inclosure is too broken upon the west side to allow of its being described as rectangular. In width, between crests, the valley varies from about 12 miles near Brevard to about 25 miles near Asheville. From the base of the mountains the foot-hills extend to the low bottom-lands which border the river. Through these bottom-lands, which are seldom more than 15 feet above low water, the river meanders so as to double the shortest distance between Brevard and Asheville. Near Brevard the bottoms are 600 feet wide, but increase to one-half and one mile. The soil is sandy and produces from 30 to 50 bushels of corn to the acre. The low bottoms are sometimes swept by the floods, which leave them covered with several inches of sand, and the banks are abraded wherever the protecting fringe of trees and shrubbery has been injudiciously removed. The width of the stream appears to have changed but little, and increases gradually as one descends the river. Near Wilson's Fishtrap it is from 60 to 70 feet for a short distance; at Allison's Fishtrap it is 130 feet; at Little Buck Shoals it is 90 feet. It increases from 100 to 145, then to 340 feet at Big Buck Shoals, and diminishes to 100 feet. Below this point the descent becomes greater, the surface wider, and many rocks show themselves among the rapids. At the foot of Long Shoals the width increases to 570 feet. At Smith's Bridge it is 330 feet. From this point to the border of Tennessee the river is rapid, rugged, and picturesque. From Asheville to the Warm Springs, the distance is 37 miles and the fall 651 feet; from thence to Newport the distance is 31 miles and the fall 263 feet. It is evident that Asheville is the terminus of any practicable plan of improvement, and that an improvement which can at this time be recommended must terminate at Big Buck Shoals, near the Buncombe County line.

To return to the description of the upper part of the river, it will be noticed that the depth has the same uniform character as the width. The depth on the bars in the channel varies from 1 to 2 feet. Some of the intervening pools have a depth of from 2½ to 4 feet, with a prevalence of 4 feet; others vary from 4 to 6 feet in depth; at two points the unusual depth of 14 feet was found.

The bed of the river is covered with a shallow stratum of coarse sand and gravel, and sometimes the current is interrupted with ledges and bowlders. At Davidson's River solid rock was found at depths of 1 and 1½ feet below the gravel.

The descent of the river as far as Big Buck Shoals is more moderate and more gradually distributed than is usual in mountain streams. The distance from Wilson's Fishtrap to Big Buck Shoals is 31.49 miles, the total fall 53.809 feet; average fall per mile 1.709 feet; average fall per foot, .000.324 foot. The distance from the head of Big Buck Shoals to Smith's Bridge is 16.86 miles, the fall 77.135 feet, average fall per mile 4.575 feet. The total distance from Wilson's Fishtrap to Smith's Bridge is 48.35 miles, the total fall 130.944 feet, and the average fall per mile 2.708 feet. The distance from Brevard to Asheville in a straight line is 24½ miles; by river, the distance is 48.35 miles. The actual level of the two towns is nearly the same. Brevard is 128.07 feet above low water at Wilson's Fishtrap, while Asheville is 260.76 feet above low water at Smith's Bridge and 2,250 feet above the level of the sea.

Although the river is fordable at many points during low water, it is impassable at high water, as the floods often reach 15 feet above low water. Several bridges resting on pile piers connect the roads of Tran-

sylvania and Henderson Counties. Their position and dimensions are given in the following list.

Name of bridge.	Distance from Wilson's Fishtrap.	Height of floor above low water.	Length of bridge.	Length of span.	Kind of bridge.
	Miles.	*Feet.*	*Feet.*	*Feet.*	
Wilson's Bridge	0.71	18	163	42	Pile piers spanned by girders.
Patton's Bridge	6.28	20	161	44	
Allison's Bridge	7.18	15	113⅛	45	
Shuford's Bridge	10.52	18	141	48	
McLain's Bridge	19.51	21	138	37	
Johnson's Bridge	23.1	19 6/10	162	38	
King's Bridge	25.7	15 6/10	187	50	

All of these bridges will need to be raised or provided with draws to admit the passage of steamers. This work would be done by the county authorities.

The special characteristics of the river compiled from the notes of the survey are given in the following table, which includes the measured length, width, depth, and descent or fall of the river, also the approximate amount of excavation required to obtain a depth of 2½ feet at low water with an average width of 37 feet. By this means and by the aid of lateral dams it is proposed to secure 2½ feet at low water as far as Big Buck Shoals.

Table showing approximate amount of excavation required to obtain a depth of 2½ feet at low-water with an average width of 37 feet.

Name of shoal.	Reference number on map.	Location. Head of shoal opposite transit station.	Location. Foot of shoal opposite transit station.	Distance from Station O to foot of shoal.	Fall from surface of low-water at Station O to foot of shoal.	Length of shoal.	Fall of shoal.	Average depth of water.	Average width of river.	Excavation.		Character of material of bed of river.	Remarks.
				Miles.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Cubic yards.*			
Wilson's Fish-trap	1	0	2+55	.05	0.300	250	0.300	2.2	60	28.8		Gravel and loose rock	Excavation for a channel 40 feet wide at top, 34 feet at bottom, and 2½ feet at low-water.
Wilson's Bridge	2	18+0	20+50	.31	.....	250	.....	2.1	60	116.0		Sand and gravel	
	3	45+80	46+0	.80	3.269	20	.104	2.2	60	1.8		Sand	
	4	48+70	49+20	.86	.....	50	.....	2.3	60	10.2		Gravel	
	5	51+90	52+40	.92	.....	50	.....	2.1	60	15.0		do	
	6	65+10	67+90	1.18	3.751	280	.....	2.2	55	98.2		Gravel and sand	
	7	74+50	74+80	1.3	.....	30	.....	1.8	55	24.1		Rock	
	8	89+10	90+10	1.59	.....	100	.....	2.3	46	22.6		Sand	
	9	110+80	111+20	2.00	.....	40	.....	2.3	58	8.2		do	
	10	119+50	119+90	2.18	.....	40	.....	1.9	60	11.4		Rock	
	11	157+50	158+30	3.00	.....	80	.....	2.3	48	19.4		Sand	
Glen Creek	12	222+78 223+80 226+00	223+60 224+40 229+30	4.34	8.710	472	1.230	2.1	60 65 80	47.7 10.2 156.4	214.3	Rock and sand	
Graham's Ford or Davidson's River.	13	283+20	289+40	5.44	10.573	620	1.588	1.9	75	424.4		Gravel and rock	
	14	293+90	295+40	5.52	.....	150	.....	2.3	70	21.3		Sand	
	15	295+70	297+90	5.57	.....	220	.....	1.7	75	231.2		Rock and gravel	
	16	309+40	310+20	5.85	.....	80	.....	2.1	80	31.1		Gravel	
	17	321+30	323+30	6.07	.....	200	.....	2.1	85	104.9		do	
Patton's Fish-trap	18	325+0	326+50	6.14	13.443	150	1.470	2.1	95	69.2		Compact gravel and loose rock.	
	19	327+30	329+50	6.19	.....	220	.....	2.0	95	160.1		Sand and gravel	
	20	331+20	332+20	6.24	.....	100	.....	2.3	115	19.5		Gravel	
	21	336+30	338+40	6.35	.....	210	.....	2.3	130	54.7		Rock and gravel	
	22	359+30	359+50	6.77	.....	20	.....	2.3	135	3.9		Gravel	
Allison's Fish-trap	23	362+0	362+40	6.82	15.297	40	.830	2.2	135	15.7		Compact gravel and loose rock.	
	24	367+40	369+20	6.94	.....	180	.....	1.7	135	204.9		Gravel	
	25	375+50	376+90	7.07	.....	140	.....	2.0	120	72.3		do	
	26	394+10	395+40	7.41	.....	130	.....	2.1	80	62.9		do	
	27	400+70	401+0	7.50	.....	30	.....	2.2	80	11.7		do	
Cherokee Shoal	28	407+40 408+60	407+90 408+90	7.66	16.878	80	.973	2.2	75	25.5		Bowlders	
Cherokee Reef	29	411+40 415+10	413+30 415+50	7.76	.....	190	.....	2.2	85	68.1		Gravel and rock	
	30	416+10	416+30	7.81	.....	60	.....	2.3	95	11.1		Gravel	
Clayton's Ford	31	421+20	425+30	7.95	19.006	410	.580	1.9	95	319.4		Sand and gravel	

	32	426+50	426+80	8.00	.....	30	.....	2.2	80	15.6	Gravel.....	
	33	428+60	429+40	8.05	.....	80	.....	2.4	75	5.2	.....do.....	
	34	431+20	431+60	8.09	.....	40	.....	2.3	75	10.5	Sand.....	
	35	432+30	432+50	8.11	.....	20	.....	2.3	80	3.9	Gravel.....	
	36	435+90	437+20	8.20	.....	130	.....	2.1	85	12.1	Mud.....	
	37	438+80	439+10	8.23	.....	30	.....	2.3	85	5.8	Gravel.....	
	38	453+80	454+60	8.49	.....	50	.....	2.3	95	13.1	.....do.....	
	39	457+40	458+80	8.56	.....	140	.....	2.3	85	34.6	.....do.....	
Little Buck.....	40	486+20	490+20	9.12	22.500	400	1.392	2.2	85	157.3	Rock.....	
	41	490+70	491+30	9.14	.....	60	.....	2.3	90	18.3	Gravel.....	
	42	491+80	492+70	9.17	.....	90	.....	2.4	90	15.6	.....do.....	
	43	504+80	510+70	9.47	.....	590	.....	2.1	90	274.7	Sand and gravel.....	
Old Ford.....	44	549+70	551+10	10.23	25.344	140	.100	2.1	105	67.1	Compact gravel.....	
Shuford's Bridge.....	45	570+26	573+0	10.62	26.290	274	.617	.....	100	.....	.....	Caused by drift, &c.
Clayton's Reef.....	46	590+55	591+90	10.96	.....	135	.....	2.15	115	60.5	Rock.....	
	47	736+30	736+40	13.50	.....	10	.....	2.3	120	1.9	Sand.....	
Henry's Fish-trap.....	48	.....	789+66	14.50	32.451	.....	.345	.....	125	40.	Loose rock, &c.....	
	49	885+75	885+87	16.48	.....	12	.....	2.45	130	.9	Sand.....	
	50	921+90	922+50	16.95	.....	60	.....	2.3	130	15.0	Gravel.....	
	51	923+90	924+25	17.00	.....	35	.....	2.4	120	4.5	.....do.....	
	52	926+90	927+80	17.07	.....	90	.....	2.25	115	30.7	.....do.....	
	53	930+40	930+50	17.11	.....	10	.....	2.4	105	1.2	.....do.....	
Gash's Fish-trap.....	54	.....	1146+0	21.10	41.412	.....	.393	.....	105	50.	Loose rock, &c.....	
Spann's Shoal.....	55	1428+35	1432+43	26.53	47.474	408	1.003	2.1*	125	55.0	Rock.....	
	56	1538+20	1538+72	28.50	.....	52	.....	2.0	135	31.1	Rock and gravel.....	
	57	1547+0	1547+95	28.67	.....	95	.....	2.3	140	24.1	Gravel.....	
	58	1571+90	1572+05	29.14	.....	15	.....	2.35	145	1.8	.....do.....	
Cane Creek.....	59	1587+40	1588+60	29.46	.....	120	.....	1.9	145	109.8	.....do.....	
	60	1612+60	1613+90	29.92	.....	130	.....	2.45	125	8.5	Sand.....	
	61	1614+60	1616+80	29.97	.....	220	.....	2.35	130	46.3	Sand and rock.....	
Big Buck Shoals.....	62	1698+00	1720+80	31.90	56.590	2,280	2.781	.....	.....	.....	.....	
Hickory Flat.....	63	1767+19	1783+24	33.13	59.203	1,605	.400	.....	.....	.....	.....	
Long Shoal.....	64	1830+50	1950+70	36.44	77.813	12,920	18.277	.....	.....	.....	.....	
Sandy Bottom.....	65	1965+0	2145+58	39.80	100.628	18,058	22.628	.....	.....	.....	.....	
Taylor's Ford.....	66	2165+0	2178+45	40.35	104.016	1,345	2.713	.....	.....	.....	.....	
	67	2281+88	2286+58	42.32	107.890	162	.877	.....	.....	.....	.....	
	68	2293+0	2294+0	42.48	108.508	100	.335	.....	.....	.....	.....	
Patton's Bridge.....	69	2322+70	2325+07	43.04	112.138	237	2.161	.....	.....	.....	.....	
Bell's.....	70	2331+0	2350+0	43.48	116.005	1,900	2.874	.....	.....	.....	.....	
Tennant's Fish-trap.....	71	2469+0	2470+50	45.23	122.165	150	1.070	.....	.....	.....	.....	
Patton's Fish-trap.....	72	2501+0	2503+0	45.87	124.281	200	.805	.....	.....	.....	.....	
Swannanoa.....	73	2543+0	2545+0	46.68	125.348	200	.306	.....	.....	.....	.....	
Roberts.....	74	2592+0	2595+0	47.69	128.817	300	.871	.....	.....	.....	.....	
Smith's Bridge Shoals.....	75	2616+0	2618+0	48.11	130.782	200	.964	.....	.....	.....	.....	
Surface at Smith's Bridge..	76	.....	2631+4	48.35	130.944	.....	.....	.....	.....	.....	.....	

*For 60 feet. This shoal includes two reefs.

The total amount of excavation from Wilson's Fish-Trap to the head of Big Buck Shoals is 3,597 cubic yards.

The following table shows the length and fall of the two sections of the river referred to above.

	Distance.	Fall.	Fall per mile.
	Miles.	*Feet.*	*Feet.*
From Wilson's Fish-Trap to head of Big Buck Shoals	31.49	53.809	1.709
From head Big Buck Shoals to Smith's Bridge	16.86	77.135	4.575
Total	48.35	130.944	2.708

OSCILLATIONS OF THE RIVER.

In small and rapid streams like the French Broad, the rise and fall of the water has a more important relation to the navigation than in larger streams. The high water may be often utilized for a navigation which is impracticable at low water, and a stream may be improvable at higher stages which cannot be fitted for navigation at the lowest. Hence the importance of accurate information relating to the rise and fall of the water and to the movement of drift and ice.

Three gauge stations were established, the first at Wilson's Bridge, the second at Shuford's Bridge, and the third at Big Buck Shoals. Observations were begun about the first of August, and have been taken twice each day up to the present date. During the past six months the rise and fall of the river seem to have been sufficiently gradual, and the duration of the high water sufficiently long to be made available for navigation. For two months the surface has averaged 6 inches above zero, and during four months it has ranged from 1 to 9 feet above. The time of falling is less rapid than that of rising, the most rapid rise being at the rate of 5½ inches per hour.

The following table gives the gauge observations to February 1, 1878:

Table of oscillations.

GAUGE READINGS.

Day of month.	August.			September.			October.			November.			December.			January.		
	Wilson's Bridge.	Shuford's Bridge.	Buck Shoal.	Wilson's Bridge.	Shuford's Bridge.	Buck Shoal.	Wilson's Bridge.	Shuford's Bridge.	Buck Shoal.	Wilson's Bridge.	Shuford's Bridge.	Buck Shoal.	Wilson's Bridge.	Shuford's Bridge.	Buck Shoal.	Wilson's Bridge.	Shuford's Bridge.	Buck Shoal.
1	0.3	0.5	....	0.1	0.2	0.3	−0.1	0.2	0.3	0.2	0.8	0.8	1.3	2.7	1.7	2.6	4.3	....
2	0.1	0.6	....	0.1	0.2	0.2	0.1	0.2	0.2	3.5	4.1	2.4	1.2	2.5	1.0	2.1	3.7	....
3	0.1	0.7	....	0.1	0.3	0.2	0.2	0.9	0.3	2.1	3.2	3.0	1.0	2.3	0.6	1.9	3.6	....
4	0.1	0.5	....	0.1	0.8	0.1	3.1	4.6	3.6	1.1	1.1	2.2	1.1	2.3	0.3	2.0	3.5	....
5	0.1	0.5	....	0.1	1.0	0.2	1.3	2.3	3.2	1.0	1.3	1.9	4.8	6.1	1.1	1.7	3.4	....
6	0.1	0.8	....	0.2	1.6	0.6	0.2	1.3	1.9	1.0	2.0	1.6	4.5	8.0	1.7	1.6	2.7	....
7	0.1	0.5	....	0.1	0.6	0.5	0.1	1.0	1.3	0.8	1.5	1.4	3.0	4.4	1.6	1.5	2.6	1.3
8	0.1	0.5	....	0.1	0.2	0.4	2.7	3.7	3.6	5.1	5.4	3.2	2.4	3.8	1.3	1.4	2.6	1.1
9	0.1	0.5	....	0.1	0.2	0.2	1.4	3.2	2.3	5.0	(*)	6.1	1.7	3.7	1.1	1.9	3.9	1.5
10	0.1	0.5	0.4	0.2	0.5	0.4	0.7	1.9	1.3	2.4	4.4	5.2	1.6	3.3	0.7	5.3	8.1	5.0
11	0.1	0.6	0.3	0.5	0.8	1.4	0.5	1.4	1.2	1.7	3.2	3.5	1.5	2.6	0.5	3.3	5.5	4.4
12	0.1	0.6	0.3	0.1	1.0	1.1	0.3	1.1	1.2	1.3	2.6	2.5	1.5	2.5	0.4	2.6	4.4	3.1
13	0.2	0.5	0.5	0.1	1.0	0.8	0.3	1.0	1.1	1.1	2.1	2.0	1.3	2.4	0.3	4.3	4.2	2.7
14	0.1	1.2	0.8	0.1	0.6	0.7	0.3	0.9	0.9	0.9	2.2	1.5	1.2	2.3	0.2	4.0	5.9	3.9
15	0.1	0.8	0.6	0.1	0.4	0.6	0.2	0.8	0.8	0.9	1.9	1.3	1.2	2.3	0.1	3.3	5.0	3.2
16	0.1	0.6	0.4	0.1	0.4	0.5	0.1	0.7	0.8	0.8	1.7	1.0	1.1	2.1	0.3	2.9	4.2	5.2
17	0.1	0.5	0.3	0.1	0.3	0.5	0.4	0.6	0.7	0.8	1.6	0.8	1.0	2.0	0.3	2.6	3.8	2.1

Table of oscillations—Continued.

GAUGE READINGS.

Day of month.	August.			September.			October.			November.			December.			January.		
	Wilson's Bridge.	Shuford's Bridge.	Buck Shoal.	Wilson's Bridge.	Shuford's Bridge.	Buck Shoal.	Wilson's Bridge.	Shuford's Bridge.	Buck Shoal.	Wilson's Bridge.	Shuford's Bridge.	Buck Shoal.	Wilson's Bridge.	Shuford's Bridge.	Buck Shoal.	Wilson's Bridge.	Shuford's Bridge.	Buck Shoal.
18	0.1	0.5	0.3	0.1	0.4	0.5	0.1	0.6	0.6	0.7	1.5	0.5	0.9	1.9	0.2	2.2	3.5	1.8
19	0.1	0.5	0.3	0.4	1.1	0.5	0.1	0.5	0.5	0.6	1.4	0.3	0.9	1.9	0.1	2.0	3.5	1.6
20	0.1	0.2	0.3	1.5	2.8	1.3	1.0	1.3	0.8	0.6	1.3	0.3	0.8	1.8	0.1	3.8	4.0	2.2
21	0.1	0.2	0.3	0.8	1.2	2.2	1.7	3.8	2.5	2.3	3.7	0.2	0.8	1.7	0.0	3.3	4.8	2.9
22	0.1	0.1	0.2	0.2	0.7	1.5	0.7	1.7	1.8	7.7	(*)	5.7	0.9	1.7	0.1	2.6	4.2	2.3
23	1.2	2.0	0.1	0.1	0.7	1.0	0.4	1.2	1.4	4.9	(*)	6.4	1.3	2.2	0.2	2.3	3.8	2.0
24	0.2	1.1	1.2	0.1	0.6	0.7	0.4	1.0	1.2	4.6	(*)	6.6	3.1	4.4	.....	2.1	3.4	1.6
25	0.1	0.5	0.6	0.1	0.6	0.6	0.3	1.0	1.1	3.6	6.0	5.4	6.3	7.9	.....	2.0	3.2	1.5
26	0.1	0.4	0.4	0.1	0.5	0.5	0.3	1.0	1.0	3.3	5.8	4.2	4.7	8.4	.....	1.8	3.1	1.4
27	0.1	0.2	0.3	−0.1	0.4	0.5	0.7	1.5	1.5	2.5	4.1	3.5	2.7	4.6	.....	2.1	3.0	1.3
28	0.1	0.5	0.6	−0.2	0.4	0.4	0.3	1.4	1.3	1.9	3.5	2.9	2.2	3.8	.....	2.2	3.8	2.9
29	0.1	0.8	0.8	−0.2	0.3	0.4	0.3	1.0	1.2	1.8	3.2	2.5	4.3	5.3	.....	1.8	3.2	1.5
30	0.1	0.5	0.6	−0.2	0.3	0.3	0.2	0.9	1.1	1.5	2.4	2.1	6.1	9.3	.....	1.9	3.2	1.3
31	0.1	0.5	0.4	.....	...	....	0.2	0.8	1.0	.....	.....	.....	3.7	5.7	.....	2.1	3.2	1.3

* Over gauge.

DISCHARGE.

Discharge measurements were made near James Davis's house. From Davidson's River to Little Buck Shoals is 3.7 miles, and upon this part of the river by far the larger part of the proposed expenditure for improvement will have to be made. A well determined discharge at this point would have been all that was required. The measurements of velocities, however, were imperfect. I, therefore, determined to use the formula of Kutter, which seems adapted to mountain streams, and which gives a result sufficiently near the truth to be used until more accurate observations can be made in the spring.

The formula of Kutter is based on the well-known formula of D'Arcy and Bazin, in which the values of the co-efficient *c* are made to vary with "the value of *r*, the hydraulic mean depth, and the condition of the section. These conditions are classed in four categories, which do not include every degree of roughness of the wetted perimeter," but which may be made to include small values of the co-efficient *c* by interpolations and additions suitable to observed cases.

Employing the formula for English feet,

$$v = \left\{ \frac{41.6 + \frac{1.811}{n} + \frac{0.00281}{J}}{1 + \left(41.6 + \frac{0.00281}{J}\right)\frac{n}{\sqrt{R}}} \right\} \sqrt{RJ}$$

in which v = mean velocity of discharge, feet per second.

$R = 3.23787$ feet = hydraulic mean depth.

$J = .000243706$ = the sine of the inclination of the water-surface.

$n = 0.030$ = coefficient dependent on material over which the water flows, which, in case of rivers obstructed by gravel and stone in a moderate degree, equals 0.030.

We have then

$$\frac{.00281}{J} = \frac{.00281}{.000243706} = 11.5303$$

$$\sqrt{R} = 1.8 \therefore \frac{n}{\sqrt{R}} = \frac{0.3}{1.8} = .016666 +$$

Also,

$$\sqrt{R}J = .0280907$$

Substituting these values in the equation for v and reducing,

$$v = \frac{113.46363}{1.885505} \times .0280907 = 1.69004 \text{ ft. per second.}$$

The area of the cross-section is 340.3 square feet, and the discharge 575.107 cubic feet per second.

This discharge is smaller than the observed discharge, but as the latter was based on several uncertain observations, I have thought it safer to employ the result obtained as above in all the following calculations.

We are now prepared to consider the method of improvement.

IMPROVEMENT.

Before presenting the plans and estimates for improving the river, it is proper to state the considerations and conditions which must determine the character of the plan as well as the scale of the improvement. While the latter is limited by the resources of trade and industry, the character of the improvement is limited by other conditions. The more important of these may be mentioned as follows:

1. Assuming that any elevation of the low-water level may damage the bottom lands, the first condition involves the preservation of the present level.

2. The average depth of the river is nearly 2½ feet, and any improvement which contemplates an increase of depth to over 2½ or 3 feet will be more expensive than the present or future trade will justify. This will be made more apparent in the estimates to be submitted.

3. A depth of 2½ feet will afford sufficient depth for barge navigation or unloaded steamers, which consequently would not be of much use except in the higher stages.

4. In order to obtain the depth of 2½ feet at low-water, it will be necessary to excavate through the bars and to contract the water-way. The contraction should not be such as to increase the velocity above the average of 3.3 miles per hour nearly, so as to keep within the limits of the natural velocity. This will permit steamers of moderate power to ascend the river and barges may be warped up without much difficulty. The natural current sometimes reaches 4 miles an hour, but in low stages averages about 2.

These considerations are important, as the navigation can only be adapted to small steamers of light draught and small power.

The average sectional area of the river is about 270 feet, and the conditions governing the movement of such steamers would be nearly the same as in an indefinite fluid, according to the formula of Du Buat—

$$P' = P\frac{8.46}{\frac{c}{s}+2}$$

in which

c = the section of the canal.
s = the section of the part of a prism plunged in the water.
P = the resistance which the prism experiences in an indefinite fluid.
P' = the resistance experienced in the canal.

Any contraction, therefore, will at once cause a resistance to the motion of the boat. This resistance can be approximately determined when the size and model of the boat are known. Assuming a midship section of $18' \times 2\frac{1}{2}' = 45$ square feet, and a length of 75 feet, we obtain a capacity of 80 tons, including machinery and boat, according to the experiments made on the Languedoc Canal, and of about 100 tons for a boat 90 feet long, suitable for the navigation of the French Broad; and making these models the basis of calculation, we obtain the resistance to a similar body moving in a fluid by the formula of D'Aubuisson.

$62.43\ n\ s\ h' =$ pounds pressure, in which

$n = 1.34 =$ coefficient of "*denivellation.*"

$s =$ section of boat.

$h' =$ the height due to the velocity.

When the body is itself in motion, $h' = \left(\frac{v \mp u}{2g}\right)^2$ in which $v =$ velocity of current $= 4$ miles per hour $= 5.866$ feet per second, $u =$ velocity of boat $= 5$ miles per hour $= 7.333$ feet per second, taking an extreme case. The resistance $= 62.43\ n\ s\ h = 10.801$ pounds $= P'$.

Correcting this result by the formula obtained from the Languedoc Canal experiments $P'' = P'\left[1 - 0.26\left(\frac{c}{s} - 1\right)\right]$ we obtain the resistance to a boat moving at the rate of 5 miles an hour against a current of 4 miles per hour in a channel 3 feet deep. This resistance is equivalent to a tractive force of 5.7 tons. But in order to determine the actual steam-power required to propel a boat of the same model and under the same circumstances, the immersion of the paddles, effect of the current, and friction of the machinery must be considered. D'Aubuisson suggests the following expression for the determination of the dynamic effect:

$$.1142\ S\left(\sqrt{\frac{S}{s}} + 3\right)(\pm V \mp u)^3$$

V being the velocity of the river, u that of the boat, S the immersed section midships of the boat, s the surface of that portion of the paddles immersed=say 8 square feet. The upper signs refer to the case where the boat ascends, the lower signs to that where it descends.

We thence obtain for the power required for a fine model 66,992 pounds. In order to obtain the resistance to a barge-shaped model in the contracted channel (40 feet wide), the formula for the effect of contraction must be applied to the above results, and to this must be added the loss by friction ($\frac{1}{5}$) and a coefficient (2.4) deduced from the experiments of M. Maguès on the Languedoc Canal, (*D'Aubuisson's Hydraulics, translation*, p. 296.)

The formula will take the form—

$$P' = \left[\left(P \cdot \frac{8.46}{\frac{c}{s} + 2}\right) + \left(\frac{P}{5} \cdot \frac{8.46}{\frac{c}{s} + 2}\right)\right] 2.4 = 350{,}167 \text{ pounds.}$$

or $10\frac{2}{3}$ horse-power.

This result is merely approximate, but it is sufficient to show that steamers of 80 to 100 tons and from 12 to 15 horse-power are suitable to the navigation of the French Broad River in its proposed improved condition.*

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* A light-draught steamer of Bessemer steel has recently been built by Yarrow & Co., of Poplan, England, of the following dimensions and draught: Length 124 feet, beam 24 feet, unloaded draught 13 inches, loaded draught 2 feet 1 inch, speed $10\frac{1}{2}$ miles per hour; and iron steamers of the same capacity and draught are built in Norfolk, Va.

METHODS OF IMPROVEMENT.

Three methods of improvement may be employed:

1st. French movable dams with locks.

2d. American system of locks and dams.

3d. Wing-dams and excavation.

1. *Movable dams.*—Although the river is peculiarly well adapted to the French system, I have, after consideration of the cost of construction and maintenance, concluded to dismiss it as too expensive. The second and third systems will be compared in the following pages.

2. *Locks and dams.*—It will appear from the following statement that the greatest fall occurs in a limited distance, and that above and below this locality the descent is moderate and uniform.

Locality.	Distance.	Fall.	Fall per mile.
	Miles.	*Feet.*	*Feet.*
From Wilson's Fishtrap to Davidson's River	5.33	8.985	1.681
From head of Davidson's River to foot of Little Buck Shoals	3.77	13.515	3.585
From foot of Little Buck Shoals to head of Big Buck Shoals	22.39	31.309	1.400
Wilson's Fishtrap to Big Buck Shoals	31.49	53.809	1.71

The fall of little more than 13½ feet in a distance of $3\frac{7}{10}$ miles is confined chiefly to four points between Davidson's River and Little Buck Shoals. Two dams, about 50 feet long and $8\frac{9}{10}$ feet high, and two locks, with an average lift of 7 feet, will be sufficient to secure a depth of 3 feet in this part of the river at low water.

From Brevard to the upper lock, and from the lower lock to Big Buck Shoals, the river can be easily improved by several small dams and the excavation of a channel through the bars.

This method, although affording a satisfactory depth, is liable to one objection. There is no doubt of a small overflow of bottom-land in the vicinity of Allison's Fishtrap, and the extent of bottom which would be covered at flood can only be determined by special survey. The propriety of damming the river will, therefore, depend on the relative value of the probable trade and the present value of the land. These questions, I think, should be decided by the land-owners who are interested. I have, however, thought it my duty to present an estimate of the cost of improving the river by this method on account of the unquestionable superiority of the navigation which it would afford. The estimate is based on a plan for a composite lock of crib-work filled with stone, the dimensions being 100 by 20 feet in the chamber and between the gates.

The lift is 7 feet in each case. A plan of the proposed lock accompanies the report, together with a special sheet showing the location of the dams. The dams will be of crib-work, with suitable abutments and securely bolted to the rock foundation, 8.9 feet in average height. The heights were obtained by successive approximations of the formula

$$H = \sqrt{\left(\frac{Q}{3.33\,L - .333\,n\,H}\right)^2}$$

derived from the formula of Francis, in which—

Q = the discharge in cubic feet per second.

L = the length of the dam.

n = the number of end contractions.

H = the height.

The distance between the dams is 1.83 miles.

ESTIMATE FOR THE IMPROVEMENT OF FRENCH BROAD RIVER FROM WILSON'S FISH-TRAP TO THE HEAD OF BIG BUCK SHOALS BY LOCKS AND DAMS. CHANNEL THROUGH BARS 40 FEET WIDE AT TOP, 34 FEET AT BOTTOM, AND 3 FEET DEEP.

Excavation above Davidson's River, 3,241.2 cubic yards at $4	$12,964 80
Lock at head of Cherokee Shoal (including excavation for foundation)	15,162 33
Dam for the same, 80 feet long, 9.3 feet high	10,563 00
Lock below Little Buck Shoal (including excavation for foundation)	15,162 33
Dam for the same, 90 feet long, 8.5 inches high	10,504 00
Excavation from this lock to head of Big Buck Shoal	12,098 00
	76,454 46
Contingencies 10 per cent	7,645 44
	84,099 90

3.—*Improvement by lateral dams and groins so as to give 2½ feet at low water.*—In this report I will call by the name of groins such wing-dams as extend from the bank in a straight line toward the channel, and which may be either perpendicular to the thread of the current or oblique to it. Such dams may have a T-head or short wing of the same length as the groin, or if prolonged further downstream and parallel with the current, they will be called lateral dams. Groins and lateral dams are generally built with two objects in view, viz: either to concentrate the current or to raise the water surface above, or they may be designed to raise the surface and concentrate the current at the same time.

The general effect of such structures upon the movable material of a river-bed is to deepen the water at the head of the dam, and to transfer the material removed to a lower point. This is very marked in the case of groins, which are liable to another objection on account of the action of the current upon the banks below them.

Lateral dams, in addition to the advantage obtained by groins, lead the current with a more uniform descent, conduct the material in suspension to the desired point, and distribute the deposit gradually. In contracted channels and sharp bends, where a continuous stone-dike would become dangerous to navigation, the groins may be used to advantage. Where the object is simply to elevate the surface a few inches, the facility with which they may be extended so as to obtain the requisite cross-section, gives to these dams a superiority over the lateral system. Care, however, must be taken to make the cross-section of the water-way permanent by paving the bottom and protecting the banks.

In order that the two systems may be compared, I have subjoined an estimate for improving the river by lateral dams, and also by groins with occasional wings. In both cases some excavation will be necessary, and the amount is included in each estimate.

In the determination of the slope resulting from a given contraction of the natural channel, it seems proper to employ the formula which would give the largest "factor of safety." Where the cost of work is affected by uncertain contingencies, some precaution of this sort is necessary.

Instead, therefore, of the more accurate formula of Humphreys and Abbot, or of Kutter, the following formula of Rankine has been employed: (Rankine's Civ. Engineering, p. 681.)

$$i = \frac{f}{m}\left(\frac{v^2}{64.4}\right)$$

in which

i = the sine of the slope.
v = velocity in feet per second.
f = a coefficient.
m = the mean hydraulic depth.

This formula is the same as given by Trautwine under the following form:

$$F = p\left(\frac{.000114\ v^2 + .00002426\ r}{a}\right)$$

(Trautwine's pocket-book, p. 565.)

in which

F = the fall per foot (in feet).
p = the wetted perimeter.
v = the velocity in feet per second.
a = the area of cross-section.

For the elevation due to a contraction of the width, the following formula has been used:

$$n = \frac{v^2}{2g}$$

ESTIMATE FOR LATERAL DAMS.

Cross-section of water-ways, 50 feet wide by 2½ feet deep.
Slope of water-surface, .001078 feet per foot.
Slope of water-surface, 5.692 feet per mile.
Velocity of water, 4.84 feet per second.
Velocity of water, 3.3 miles per hour.

The length of the dam will be—

At Davidson's River, 2,000 feet for a fall of 2.15 feet.
At Patton's Shoal, 1,670 feet for a fall of 1.80 feet.
At Cherokee Shoal, 5,750 feet for a fall of 6.20 feet.
At Little Buck Shoal, 2,040 feet for a fall of 2.20 feet.
Total length, 11,460 feet.

Estimating this at cost of $5.50 per linear foot, a factor derived from a careful estimate of the dams, we have:

11,460 linear feet of dam, at $5.50	$63,030 00
For excavation and other work above Davidson's River and between Little and Big Buck Shoals	8,143 00
	71,173 00
Add 10 per cent for contingencies	7,117 00
Total cost	78,290 00

This estimate should be compared with the following estimate for groins and short wing-dams with a permanent cross-section, formed by paving the bottom and protecting the banks:

ESTIMATE FOR GROINS AND SHORT WING-DAMS.

Channel as above, 50 feet wide, 2½ feet deep. Maximum velocity, 4.84 feet per second, or 3.3 miles per hour.
Average height of wing-dams, 6 inches above low-water.

Excavation above Davidson's River, 712.5 cubic yards, at $4	$2,850 00
Dams at Davidson's River, 1,271 cubic yards, at $3	3,813 00
Excavation at Davidson's River, 276.3 cubic yards, at $4	1,105 20
Excavation between Davidson's and Patton's, 485.6 cubic yards, at $4	1,942 40
Dams at Patton's, 1,973 cubic yards, at $3	5,919 00
Excavations between Patton's and Allison's, 92.9 cubic yards, at $4	371 60
Dams at Allison's, 1,126 cubic yards, at $3	3,378 00
Excavation at Allison's, 39 cubic yards, at $4	156 00
Excavation between Allison's and Cherokee, 118.2 cubic yards, at $4	472 80

ms at Cherokee Shoals, 2,985 cubic yards, at $3	$8,955 00
cavation at Cherokee Shoals, 25 cubic yards, at $4	100 00
cavation between Cherokee and Little Buck Shoals, 59.7 cubic yards, at $4	238 80
ms at Little Buck Shoals, 1,543 cubic yards, at $3	4,629 00
cavation at Little Buck Shoals, 336.5 cubic yards, at $4	1,346 00
cavation between Little and Big Buck Shoals, 685.5 cubic yards, at $4	2,742 00
	38,018 80
550 feet ⅞-inch chain	2,872 50
chors	500 00
	41,391 30
d 10 per cent. for contingencies	4,139 13
Total	45,530 43

The chain included in the estimate is intended to be fastened with ıg-bolts in rocks on the bed of the river to enable boats to warp up ainst a strong current.

The method of improvement by groins, short wing-dams, and excaıtion seems to be not only better adapted to the river than the lateral ıms, but also to be the least expensive mode of improvement.

TRADE AND RESOURCES.

I am not able to offer any further information in regard to the agricul-ral products of the portion of the French Broad River, which is the bject of this report, than can be found in the first report of Mr. Mcılla, which is published in the Report of the Chief of Engineers for 75, Part I, page 819.

The outlet for the future trade of the river, and, indeed, of the entire lley, must depend upon the two railroads which, as I have stated, are ing diligently pushed toward an early completion.

Although it is not likely that the river improvements will be conıued below the Henderson County line, yet a connection will be made railroad with the river near the terminus of the proposed improveent.

PRESENT CONDITION OF THE WORK.

The commencement of the work of improvement by hired labor was ıthorized September 13, 1877. As specific estimates could not be made view of the uncertainty of the cost of labor and materials in such an accessible locality, this method was considered most advantageous for e preliminary operations.

The necessary materials and tools were purchased and active operaons commenced in October and continued until December 15, when ey were suspended for the winter.

A derrick-boat and two scows have been built for removing rock from e channel. The fish-traps at Wilson's and Davidson's Rivers, on raham's Ford, have been partly removed. A quarry has been opened Davidson's River, and 600 cubic yards of rock quarried for building ing-dams. The snags, drift-logs, and overhanging trees have been moved for a distance of about 20 miles from Wilson's fish-trap. Some the snags were left, as they were too large to be raised without a derck; the winter freshets will probably cause additional accumulations drift, &c., to be removed. About $4,000 will be available for the ork when operations are resumed in the spring.

GENERAL CONCLUSIONS.

Estimates for three methods of improvement are submitted in the foregoing report. The general conclusions as to the advantages and cost of each may be briefly repeated:

First. The most efficient improvement can be made by the construction of two locks and two dams, together with a small amount of excavation. The depth at low water will be 3 feet, and the entire cost $82,816.20.

Second. Two and a half feet can be secured at low-water by means of lateral dams at a cost of $78,290. This method is more costly than that of groins.

Third. Two and a half feet can be secured by short wing-dams and groins at a cost of $45,530. This form of dam can be more economically adjusted to the variable velocity and cross-section of the river, but the objection to the two last methods will be the velocity of the current at the dams, which will be about 4.84 feet per second at low water, and will increase a little until the water is over the dams.

Fourth. If Congress thinks proper to authorize either of the above-mentioned methods of improvement, it would be desirable for reasons of economy to grant the entire amount in one appropriation. The expenditures and preparations which have been made are applicable to either plan.

Fifth. The nature of the soil of which the banks are composed is such that the speed of steamers which may be used on the river should not exceed an average of 5 miles an hour.

LIST OF MAPS.

The following maps and plans accompany this report:

A general map and profile of French Broad River from Brevard to Asheville. Scale, $\frac{1}{48000}$.

One map and profile from Glen Creek Shoal to Little Buck Shoal, showing location of locks and dams. Scale, 400 feet to an inch.

One map and profile from Davidson's River to Little Buck Shoals, showing the location of the wing-dams. Scale, 400 feet to an inch.

Thirteen special sheets of obstructions. Scale, 400 feet to an inch.

Plans of locks, 2 sheets.

Very respectfully, your obedient servant,

S. T. ABERT,
U. S. Civil Engineer.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

G 14.

IMPROVEMENT OF PERQUIMAN'S RIVER, NORTH CAROLINA.

The removal of the stumps obstructing the navigation of this river near the town of Hertford was in progress when the last annual report was made. The snag-boat which had been in use on the Roanoke River was fitted up and employed for this purpose. The stumps were of cypress, apparently in the position where they had originally grown, and from 1 to 7 feet in diameter at the top. It was found that they were so firmly held in place by roots that they could not be removed by the use of snag-hooks alone; recourse was therefore had to blasting.

A hole 2 inches in diameter was bored in the center of the stump by

means of an auger welded to an iron rod and operated from the deck of the snag-boat; the depth of the hole was variable, being sometimes 4 feet. A charge of about 2 pounds (average) of No. 1 giant powder was then placed in the hole by a diver, and fired with a battery. The stump was thus split into several pieces, which were drawn up by means of a chain or snag-hooks. The stump generally split into as many pieces as there were large roots. These were removed and deposited near the river bank, where they would be out of the way. The stumps averaged 3 feet in diameter; the largest was 7 feet at the top and 10 feet at the surface of the mud. One root removed was 31 feet long and 30 inches in diameter.

The average depth of water on the stumps was 6 feet, the least 4½ feet, and the depth around them 9 feet. The tops of the stumps showed no ax-marks, although they appeared to have been cut off in some manner. One of them was found with a large hole in the top, which had been burned out, and the coals and charred wood were in a perfect state of preservation. The fibrous roots were perfect, showing that the soil immediately about them had not been moved. The bed of the river was composed of swamp mud underlaid with blue clay. The length of the channel across the bar or point where the stumps were found was 800 feet; the width of channel made was 200 feet, with a depth of 8½ feet at low-water; 79 stumps were removed, together with cypress knees and a few logs. The work was commenced June 15, 1877, and completed September 22, 1877.

Money statement.

July 1, 1877, amount available	$2,154 14
July 1, 1878, amount expended during fiscal year	1,566 90
July 1, 1878, amount available	587 24

G 15.

IMPROVEMENT OF ROANOKE RIVER, NORTH CAROLINA.

No appropriation was made for this improvement and no work has been done during the last fiscal year.

The sum of $4,000 was recommended in the last report for the removal of snags and the construction of a new snag-boat, but owing to the probable increase in the number of snags since that date, it would be advisable to fix the amount at $5,000. In addition to the removal of snags, some work could be done to advantage in repairing the dike at Indian Highland, which was injured by freshets. Pilots report an improvement in the channel at this point.

The total estimate for completing the improvement of the river in accordance with the plans submitted in previous reports is $222,000.

The following appropriations have been made:

March 3, 1871	$20,000 00
June 10, 1872	10,000 00
March 3, 1873	10,000 00
June 23, 1874	5,000 00

The nearest collection-district is Edenton, N. C.

The estimated shipments from Jamesville for the year ending June 1, 1878, as reported, are as follows:

10,000,000 feet sawed lumber (cypress, pine, and oak).
10,000,000 cypress and juniper shingles.
500 bales of cotton.
$5,000 worth of sundry articles.

The receipts are valued at about $100,000.

Money statement.

July 1, 1877, amount available	$181 98
July 1, 1878, amount expended during fiscal year	181 98
Amount (estimated) required for completion of existing project	222,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880	5,000 00

G 16.

IMPROVEMENT OF PAMPLICO RIVER, NORTH CAROLINA.

Work was commenced under the contract with Messrs. Swindell & Sparrow, of Washington, N. C., for removing the pile obstructions near Hill's Point, on August 1, 1877, and completed September 19, 1877. Eight hundred and ninety-five piles were removed. The contractors used a Spanish windlass and snag-hooks. The piles, when drawn, were taken on shore and piled securely.

The river was carefully examined with a "sweep," and all the piles that could be found were removed.

Dredging under the contract with Mr. G. H. Ferris, of Baltimore, was commenced October 1, 1877. A channel 175 feet wide was dredged through the bar near the town of Washington. This work was completed January 1, 1878, when operations were suspended.

Pilots and captains of vessels navigating the river having requested that some further dredging be done at a shoal part of the river about one mile below Washington, a survey of the locality was made in February, 1878. It was found that the navigation of the river could be improved by deepening the channel from 1 to 2 feet at this point. Work was accordingly resumed March 29; but it was soon found that the bed of the river was composed of a mass of roots and stumps, which, being covered with sand and mud, were not detected until the dredging was commenced. As the contract was intended to cover ordinary dredging simply, the contractor asked to be relieved of his contract or to be paid for the removal of the stumps. An examination of the work was made, and it was found that the difficulties of the work were so great that the contractor was fairly entitled to be paid for the new and unexpected kind of work he had encountered. With the sanction of the Chief of Engineers, his contract was accordingly modified to cover the removal of the stumps.

The work has, however, been of the most expensive and difficult character, causing almost constant breakage of the dredge and frequent delay therefrom. Two hundred and eighty-seven stumps were removed by the machine, without the use of powder. A great many of these were cypress knees, the least diameter being 5 inches and the greatest diameter of the stumps 4 feet. All the cypress stumps were perfectly sound and in their natural position; the roots in general were about 10 feet long and from 2 to 8 inches in diameter. The gum stumps were partially decayed, the heart being sound and in its natural position. All the gum and cypress which were removed on the west of buoy 13 had been sawed off level with the bed of the river—probably in 1847, when this river was improved to some extent by the United States. Some of the stumps, on being removed, had an appearance and consistency like that of cheese, becoming hard on exposure to the air.

Work was completed under Mr. Ferris's contract on June 22, the lower channel being 70 feet wide with an average depth of about 9½ feet at low-water.

If it is desired to widen and straighten this channel, the balance of the original estimate, $10,000, will be required.

One appropriation has been made for this work, viz, that of August 14, 1876, $15,000.

The shipments are estimated as follows:

Cotton, 35,000 bales, valued at	$1,400,000 00
Naval stores	200,000 00
Lumber, &c	240,000 00
Estimated value of receipts	350,000 00

Money statement.

July 1, 1877, amount available		$14,636 04
July 1, 1878, amount expended during fiscal year		12,565 47
July 1, 1878, amount available		2,070 57
Amount (estimated) required for completion of existing project		10,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		10,000 00

G 17.

IMPROVEMENT OF NANSEMOND RIVER, VIRGINIA.

Work under the contract with Mr. G. H. Ferris, of Baltimore, Md., was commenced July 11, 1877. The channel at Suffolk was widened to 80 feet, with a depth of 8 feet at low-water, and a channel of the same dimensions was excavated through Shingle Creek Bar a short distance below Suffolk.

The dredging was completed August 20, 1877, the amount of material dredged being 8,340 cubic yards. The repairs to the dike at the mouth of the Western Branch under the same contract were commenced October 1, 1877, and completed November 3, 1877. One hundred and thirty-five sections of dike were repaired by driving front and rear piles in the middle of each section and connecting them by a tie bolted to each pile at the top and passing over the dike.

A survey of the channel at this point was made October 24, 1877, and it was found to be in good condition, the ruling depth being 10 feet at low-water.

The work proposed under the appropriation of June 18, 1878, is the completion of the repairs to the dike (which was built in 1873–'74). The improvement will then be finished, and no further appropriation will be required.

The original estimate for this work was $30,000, but its distribution over a long period of time and the repairs which have been required have increased the total to $37,000.

The following appropriations have been made:

March 3, 1873	$15,000 00
June 23, 1874	10,000 00
March 3, 1875	5,000 00
August 14, 1876	5,000 00
June 18, 1878	2,000 00

Money statement.

July 1, 1877, amount available	$4,740 52	
Amount appropriated by act approved June 18, 1878	2,000 00	
		$6,740 52
July 1, 1878, amount expended during fiscal year		4,639 79
July 1, 1878, amount available		2,100 73

APPENDIX H.

ANNUAL REPORT OF LIEUTENANT-COLONEL Q. A. GILLMORE, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1878.

UNITED STATES ENGINEER OFFICE,
New York, July 12, 1878.

GENERAL: I have the honor to transmit herewith my annual reports upon the works of river and harbor improvement under my charge for the fiscal year ending June 30, 1878.

Very respectfully, your obedient servant,

Q. A. GILLMORE,
Lieut. Col. of Engineers, Bvt. Maj. Gen., U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

H 1.

IMPROVEMENT OF THE HARBOR OF CHARLESTON, SOUTH CAROLINA.

During the fiscal year ending June 30, 1878, very little work was carried on in Charleston Harbor.

The outer end of the Bowman jetty was lowered to a level of 2 feet above mean low-water for an additional length of 30 feet. The stone which it was necessary to remove for this purpose, amounting to 200 cubic yards, were thrown into the water on either side.

Some dredging in Beach Channel was attempted by the United States dredging-steamer Henry Burden, but it was soon ascertained that she could not work there to advantage, and it was discontinued.

On the 14th of July, 1877, instructions were given to my assistant, Capt. James C. Post, Corps of Engineers, to make a survey of Beach Channel.

The results showed quite conclusively that the shortening of the Bowman jetty had not produced a wider channel at that point, but that the west end of Drunken Dick Shoal approached the Sullivan's Island shore and the jetty as fast as the latter was reduced in length. Neither was the channel deepened by the shortening of the jetty. On the contrary the greatest depths on the smallest cross-section were less than existed on the smallest cross-section four or five years ago. The crooked channel had, however, been made straight, and on the whole was in rather better condition for purposes of navigation than ever before.

Captain Post was instructed, under date of January 18, 1878, to cause borings to be made at certain specified points upon and in the vicinity of the northern end of the Charleston Bar. The object was to ascertain the general character of the beds and deposits which constitute the bar, and to determine their fitness for supporting permanent works of improvement.

The information obtained was on the whole rather satisfactory. Some of the borings were not carried deep enough to be of much value by themselves in indicating the weight-bearing capacity of the underlying beds; but taken in connection with the others, they justify the conclusion that the material of which the bar is composed is sufficiently firm to sustain works of moderate weight.

The points at which the several borings were made are shown by small circles, lettered from A to H on Plate I, accompanying my project, dated March 9, 1878, for the permanent improvement of the channel of entrance into this harbor by means of low jetties.

The character and thickness of the several kinds of material encountered in the borings is shown in the table at the bottom of Plate II of that report, prepared from the data furnished by Captain Post.

On the 25th of March instructions were sent to George Daubeney, assistant engineer, who was at that time engaged at Saint Augustine, Fla., to repair to Charleston and make some current observations on the Charleston Bar. The points selected were on a line stretching across the bar along the axis of the gap between the proposed jetties; in other words, along the North Channel. The special object in view was to determine the relation existing between the bottom and the mean ebb velocities on the outer slope of the bar, for the use of the Board of Engineers having under consideration the project for low jetties referred to above. Inclement weather interfered so seriously with this work that trustworthy results were secured at only a few of the stations. One of these was located on the outer slope of the bar in 22 feet mean low-water soundings; here it was found that the maximum ebb-velocity at the surface was about one statute mile per hour, and that the corresponding bottom velocities were only about half a mile per hour. From the observations made upon the crest of the bar directly in North Channel, in $8\frac{1}{2}$ to 9 feet soundings, it appears that the bottom ebb-velocities are at that point quite equal to the surface-velocities, ranging, when at a maximum, from $1\frac{1}{2}$ to $1\frac{3}{4}$ statute miles per hour.

The low-bottom velocities found during the ebb-tide well out on the exterior slope of the bar—low not only in point of fact, but in their relations to the velocities at the surface—would seem to point to the necessity of carrying the jetties farther seaward than the original project contemplated, thereby carrying forward the point on the bar where divergence of the flow through the gap begins.

More complete data are, however, needed on this particular point. The current observations on the bar will therefore be repeated as soon as possible during a period of calm weather, with a view to such revision of the project, with respect more especially to the length of the jetties and their distance apart, as may be suggested by more accurate knowledge of the currents on the outer slope of the bar.

WORK CONTEMPLATED DURING THE PRESENT FISCAL YEAR.

By act of Congress, approved June 18, 1878, the sum of $200,000 was appropriated "for improving harbor at Charleston, S. C."

A small part of this sum will be devoted to current and tide-gauge observations and to making additional borings, should they be deemed necessary.

The bulk of the appropriation it is proposed to expend in constructing and laying an apron to serve as the foundation of the shore end of the north or Sullivan's Island jetty, as described in general terms in the project of March 9, 1878. This apron will consist of a bottom layer

of fascine mattresses, or of a combination of timber, brush, and fascines, about 2 feet in aggregate thickness, overlaid with riprap stone adjusted in a layer of a uniform thickness of 2 feet to 2½ feet, to keep the work in place and secure it against injury from storms. The apron will be put down of the full width deemed necessary for the completed work, and will be carried out as far from the shore as possible with the money available for the purpose.

The appropriation is too small to cover the cost of the apron for the entire jetty, and some extra expense will doubtless have to be encountered in securing the sea end against damage or destruction.

The original estimated cost of the two jetties, with a half-mile gap between them, was set down at $1,800,000. The cost increases with the width of gap, and for full-height jetties, having their crests at high-water throughout, the cost of both jetties would be about $4,278,000.

The width of gap for the full-height jetties would be 1.4 miles.

These estimates are based upon the supposition that the riprap superstructure cost $5.50 per cubic yard, the mattress foundation $1.50 per square yard, and an allowance for subsidence, compression, and contingencies of 26 per cent. for the shore end and 37 per cent. for the sea ends of the jetties.

From inquiries made more recently, I am convinced that these allowances are unnecessarily large, and that $4 per cubic yard will cover the cost of riprap in place on the work and $1.25 per square yard that of the mattress foundation. I think, also, that the allowance for subsidence and compression may be safely reduced to 20 per cent. for the entire work.

The report of my assistant, Capt. James C. Post, Corps of Engineers, dated June 27, 1878, on the operations for the improvement of the harbor at Charleston during the fiscal year, is appended hereto. His report, dated August 24, 1877, on the survey of Beach Channel, made in accordance with my instructions of July 14, 1877, is also appended. The chart which accompanied this report is omitted.

This work is located in the customs-district and port of Charleston.

As tending to show to what extent the general commerce of the country will be promoted by the proposed improvement, there is submitted herewith several extracts from a letter on this subject from S. Y. Tupper, esq., president of the Charleston Chamber of Commerce, and a table of commercial statistics furnished by the collector of the port, showing the number, tonnage, and crews of vessels engaged in the foreign and coastwise trade, the value of exports, and the amount of import duties collected in each of the years 1873 to 1877, inclusive.

Money statement.

July 1, 1877, amount available	$7,368 71	
Amount appropriated by act approved June 18, 1878	200,000 00	
		$207,368 71
July 1, 1878, amount expended during fiscal year	6,392 36	
July 1, 1878, outstanding liabilities (possible)	1,000 00	
		7,392 36
July 1, 1878, amount available		199,976 35
Amount (estimated) required for completion of existing project		1,600,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880		500,000 00

REPORT OF CAPT. JAMES C. POST, CORPS OF ENGINEERS.

SAVANNAH, GA., *June 27*, 1878.

COLONEL: I have to submit the following report of the work for the improvement of Charleston Harbor, South Carolina, for the past fiscal year:

During this year operations in this harbor have been restricted, as heretofore, to the improvement of the Beach Channel entrance. The lowering of the Bowman jetty was continued till July 17, 200 cubic yards of stone being removed in addition to that reported for the previous fiscal year, and the portion of the jetty lowered to 2 feet above low-water extended 30 feet in length. At this time the work of lowering the jetty was suspended until the effect of what had been already done could be ascertained and the advisability of continuing this work determined. A survey was then made of that portion of the channel between the jetty and a point 1,350 yards to the east of it. From the extremity of this distance a line of careful soundings was also taken through the remainder of the channel and continued to deep water outside of the bar. The result of this survey indicated that the channel had not changed practically in its direction or depth throughout its extent, except in the immediate vicinity of the jetty. At this point the channel was no wider or deeper than formerly, notwithstanding the lowering of the jetty. This shows an evident tendency of the western end of Drunken Dick to approach the beach as rapidly as the jetty is lowered and the channel opened on the shore side. A number of current observations were also taken in connection with this survey, and from these it was determined that, in the portion of the channel, from the jetty to a point about 300 yards to the east of it that the flood-current commenced about 25 minutes before low-water and continued about 55 minutes after high-water; that the first of the flood passed over Drunken Dick Shoal about 300 yards to the east of the jetty, and as the tide strengthened it passed farther and farther up the channel before crossing the shoal until about half-tide, when it passed entirely through it and crossed the lowered portion of the jetty and through the opening between the jetty and the shoal. On the ebb-tide this process was reversed during the first half of it, after the ebb-current had fairly set in, and the current passed over the jetty and directly through the channel, a much smaller portion passing to the south of the shoal than during the last half of the ebb. After half-tide a large portion of the ebb-current that passed to the south of the head or western end of the shoal crossed it between the jetty and abont 300 yards to the east of it. From these observations, it is believed that in the portion of the channel before mentioned, from the jetty to a distance 300 yards to the east of it, that the observed flood-current, before low-water and after high-water, is the result of an eddy-current, caused by the ebb-current passing by the mouth of the channel and to the south of the shoal, which is its direction at the last and first of the ebb-tide. Other observations, made at different points of the harbor simultaneously showed that the flood-tide made its appearance first in the Beach Channel and afterward in each of the channels to the south of it in succession, the last of the ebb passing through what is called the main ship-channel to the Pumpkin Hill and South Channels. A detailed report of this survey was submitted to you August 24, 1877.

As soon as this survey was completed, the United States dredging-steamer Henry Burden was directed to commence dredging at the mouth or western end of the Beach Channel, with a view of increasing its size at that point, and thus cause a portion of the flood-tide that was escaping over the shoal to flow entirely through the channel. The short turn and narrow channel, with the swift currents that were encountered, rendered this dredging very slow and expensive, and it was finally given up after a trial had been made which proved conclusively that it could not be done at a reasonable cost, and, even if done, would be accompanied with uncertain results. After this no further work was done upon this channel.

To obtain data for a more comprehensive plan of improving this harbor a number of borings were made at different points in the outer harbor during the month of February. The borings were distributed so as to include the entire basin between Sullivan's and Morris Islands inside of the bar, some of them being made on the bar at the outer extremity of the North and Swash Channels. A record of these borings with their location was forwarded to you in my letter of February 25, 1878.

The vessel used in making them was a center-board sailing flat of 23 feet beam and 56 feet in length, which was moored with 4 anchors in each position. A staging was made projecting over the water from the side of the vessel, from which the borings were made, the water being too deep and the current too swift to admit of a staging being made resting on the bottom. The apparatus was an iron pipe three-sixteenths of an inch in thickness and 3 inches in diameter, made into convenient lengths of 6 feet and 8 feet, and so arranged that they could be rapidly joined together. After the pipe had been placed in an upright position on the bottom a pump or plunger about 4 feet long, having a valve at its lower end, was raised and lowered, or pumped in the pipe. Even in the hardest material encountered, by increasing the rapidity of the

pumping the pipe was made to pass quite readily into it; the material found in the plunger each time it was brought on deck, together with the measured distance of penetration, gave the different strata and their thickness through which the pipe passed. The plunger was worked from the gaff of the vessel, which was guyed directly over the pipe as it stood in the water. The borings were made almost entirely during the ebb flow of the tide, as the ebb-currents with little or no wind tend to keep out the heavy swell of the sea from the harbor. In all cases after the flat was moored it was found impossible to work more than four hours in one position, as by that time there were such changes in the currents, wind, or the amount of ocean swell that it was impossible to keep the flat in position with sufficient steadiness to continue work.

In connection with the borings, surface-currents during the different stages of the tide were also observed at each station during periods of perfect calms. The result of these observations still further proves that both the flood and ebb tides make their appearance at the north end of the bar first, their effect passing toward the south along the bar. A detailed statement of these observations was submitted February 26, 1878.

Very respectfully, your most obedient servant,

JAS. C. POST,
Captain of Engineers.

Lieut. Col. Q. A. GILLMORE,
Corps of Engineers.

REPORT OF CAPT. JAMES C. POST, CORPS OF ENGINEERS, ON SURVEY OF BEACH CHANNEL.

MOULTRIEVILLE, S. C., *August* 24, 1877.

COLONEL: I forward to-day by express the chart prepared from the survey of Beach Channel, Charleston Harbor, made in accordance with instructions received July 14, 1877.

Current observations were taken in Beach Channel, Swash Channel, near Fort Sumter, and above or west of the jetty, to determine the direction of the ebb and flood currents, and the relative times of ebb and flood slack water. Observations were also taken at the same time on the tide-gauge, which was placed on the east side of the jetty, about 50 feet from its outer end, to note the state of the tide. Mean low-water was determined on this gauge by referring it to the Coast Survey bench-mark on the custom-house steps in the city of Charleston.

The floats used consisted of pieces of 4-inch by 5-inch scantling from 6 to 8 feet long, weighted on one end so as to stand upright, with from 4 inches to 9 inches above the surface of the water.

The following are the results of these observations:

TIMES OF EBB AND FLOOD SLACK WATER.

August 1.

[Wind, S. E., light; tide, neap; slack water, ebb to flood.]

Station.	Time.	Height of water.
Middle of Beach Channel, opposite Murray's house	5.51 p. m.	3 inches above low-water.
Tide-gauge	6.40 p. m.	Low-water.

August 10.

[Wind, N., veering to S.; tide, spring; slack water, ebb to flood.]

Station.	Time.	Height of water.
Beach Channel, opposite Murray's house	1.50 p. m.	1 inch above low-water.
Tide-gauge	2.10 p. m.	Low-water.
Off jetty	2.50 p. m.	2½ inches above low-water.
Swash Channel, opposite Murray's, with Fort Johnson wharf just clearing Fort Sumter on the south.	3.15 p. m.	6 inches above low-water.

August 14.

[Wind, N. E.; tide, neap; slack water from ebb to flood.]

Station.	Time.	Direction of currents on ebb.	Direction of currents on flood.
Beach Channel, opposite Murray's	5.12 p. m.	E.	W.
Beach Channel, opposite Storehouse's	6.0 p. m.	E.	W.
Beach Channel, opposite McNulty's	6.15 p. m.	E.	W.
Beach Channel, 250 yards east of Station C on chart	6.15 p. m.	E.	W.
Tide-gauge	6.20 p. m.		
Off jetty, 20 feet on line of north front of Fort Moultrie	6.37 p. m.	S. E. by E.	N. W. by W.

August 15.

[Wind, S., light; tide, neap; slack water, flood to ebb.]

Station.	Time.	Direction of currents on flood.	Direction of currents on ebb.	Height of water.
Beach Channel, opposite Murray's.	1.24 p. m.			¼ inch above low-water.
Off jetty, on line of north front of Fort Moultrie, 300 feet from outer end of jetty.	1.15 p. m.	N. W. by N.	S. E. by E.	Low-water.
Tide-gauge	1.07 p. m.			Low-water.
Half-way between Patapsco buoy and Fort Sumter.	1.10 p. m.			Low-water.
Swash Channel, same as before.	1.30 p. m.	W. by N.	E. S. E.	1 inch above low-water.

August 15.

[Wind, S., strong; tide, neap; slack water, ebb to flood.]

Station.	Time.	Direction of currents on ebb.	Direction of currents on flood.	Height of water.
Beach Channel, same	6.40 p. m.	E.	W.	¼ inch above low-water.
Tide-gauge	7.15 p. m.			Low-water.
Off jetty, same	7.50 p. m.	E. by S.	W. by N.	
Near Fort Sumter, same	7.50 p. m.			

Sea too high to keep a boat in Swash Channel.

August 17.

[No wind; tide, neap; slack water, ebb to flood.]

Station.	Time.	Direction of currents on flood.	Direction of currents on ebb.	Height of water.
Beach Channel, same	7.45 a. m.	E.	W.	¼ inch above low-water.
Tide-gauge	8.00 a. m.			Low-water.
200 feet from Patapsco buoy toward Fort Sumter.	8.23 a. m.	E. S. E.	N. W.	1 inch above low-water.
Midway in channel, between Forts Sumter and Moultrie.	8.35 a. m.	E. by S.	W. by N.	2 inches above low-water.

August 17.

[Wind, S., fresh; tide, neap; slack water, flood to ebb.]

Station.	Time.	Direction of current on flood.	Direction of current on ebb.	Height of water.
Tide-gauge	2.45 p. m.			Low-water.
Beach Channel, same	3.20 p. m.	W.	E.	1½ inches above low-water.
Near Patapsco buoy, same	3.25 p. m.	N. W.	S. E. by E.	Do.

Current and wind so strong could not keep anchored in mid-channel to take observations.

The low-water mentioned in all of the above observations is the observed low-water for each day.

DIRECTIONS OF THE EBB AND FLOOD CURRENTS THROUGH BEACH CHANNEL.

August 1.

Slack water flood; light S. E. wind; high-water on gauge, 12.20 p. m.; 100 feet from end of jetty toward Fort Sumter ebb began 12.42 p. m.

1st float started 12.42 p. m.; course S. S. E. for 500 feet, afterward E. S. E.; 1.03 p. m. floats grounded on Drunken Dick Shoal, opposite flag-staff on chart, half-way between Murray's house and station B, in 7 feet of water.

2d float started 1.12 p. m.; tide 3½ inches below high-water on gauge; 1.15 p. m. opposite jetty and 300 feet from its course S. S. E.; 500 feet beyond jetty changed course to N. E.; 1.20 p. m. changed course to N., opposite flag-staff before mentioned; 1.22 p. m. crossed Drunken Dick Shoal to Beach Channel; 1.25 p. m. float in Beach Channel opposite Murray's house.

3d float started 1.42 p. m.; tide 9 inches below high-water; 1. 45 p. m. opposite jetty and 300 feet distant, course S. S. E.; 300 feet S. E. of jetty changed course to N. E.; opposite flag-staff crossed Drunken Dick Shoal, course E.

4th float started 2.12 p. m.; tide 1 foot 1½ inches below high-water; 2.14 p. m. passed jetty same distance as before, course same; 2.19 p. m. float crossed Drunken Dick Shoal half-way between Murray's and Steinmeyer's houses.

5th float started 2.42 p. m.; tide, 1 foot 6½ inches below high-water; passed jetty at same distance; 2.44 p. m. course same; float opposite Steinmeyer's started to cross to Beach Channel; water too rough on shoal opposite Steinmeyer's to follow float.

6th float started 3.14 p. m.; tide, 2 feet below high-water; course of float by jetty, S. E. by S.; afterward took same direction as 5th float.

7th float started 3.42 p. m.; tide, 2 feet 4½ inches below high-water; course same as last.

8th float started 4.42 p. m.; tide, 3 feet 2½ inches below high-water; course of float same as last.

9th float started 5.12 p. m.; tide, 3 feet 5½ inches below high-water; course, same; low-water 6.40 p. m.; low-water 4 feet below high-water.

August 2.

Flood-tide; light N. E. wind; neap tide, low-water on gauge 6.45 a. m.

1st float started mid-channel, opposite Steinmeyer's, 8.20 a. m.; height of water on gauge, 1 foot above low-water; float crossed Drunken Dick Shoal half way between flag-staff and station B; velocity of currents between points marked current stations on chart, 2.5 feet per second.

2d float started same place 8.44 a. m.; height of water, 1 foot 5 inches above low-water; float crossed Drunken Dick Shoal a little nearer the jetty than before; velocity, 2.8 feet per second.

3d float started same place 9.40 a. m.; height of water, 2 feet 7½ inches above low-water; float crossed Drunken Dick Shoal still nearer jetty; velocity, 2.8 feet per second.

4th float started same place 10.20 a.m.; height of water, 3 feet 5 inches above low-water; float crossed Drunken Dick Shoal opposite station B; velocity, 2.8 feet per second.

5th float started same place 11 a. m.; height of water, 4 feet above low-water; crossed Drunken Dick Shoal about same place; velocity, 2.6 feet per second.

6th float started same place 11.40 a. m.; height of water, 4 feet 5 inches above low-water; grounded on Drunken Dick Shoal about one-fourth of the distance between station B and jetty from the former; velocity, 2.4 feet per second.

7th float started same place 12.20 a. m.; height of water, 4 feet 8½ inches; passed over jetty just outside of portion lowered during past year; velocity, 2.1 feet per second; high-water on gauge, 12.45 a. m.; rise of tide, 4 feet 9½ inches.

The above observations on the flood-tide form part of a series taken opposite Steinmeyer's house every 20 minutes through the consecutive tides for obtaining the relative volumes of water passing through this channel on the flood and ebb tides.

Duration of the flood-tide $7^h\ 20^m$; duration of ebb-tide, $4^h\ 28^m$; time of flood-tide on gauge, 6^h. The flood-tide commenced 25^m before low-water, and continued 55^m after high-water. Time of ebb-tide on gauge for this day was not taken. The proportion obtained between the volumes of the ebb and flood tides on this day was 1 to 3. These observations were taken on a single line of the channel, the line of deepest water being selected. The maximum current on the flood was 2.9 feet per

second. This was obtained during its second quarter. At the end of this quarter the tide still had a velocity of 2.5 feet per second.

After this the velocity steadily decreased. A velocity of 1.5 feet per second was obtained on the ebb after the tide had fallen 10 inches, or during the first quarter. The maximum velocity, 1.55 feet per second, was obtained 40m later, when the tide had fallen 1 foot 6 inches. At half-tide, or when the water had fallen 2 feet 5 inches below high-water, this velocity was reduced to 0.5 foot per second.

Other observations on the flood current were taken August 14, at different points of Beach Channel. A brisk southeast wind was blowing at the time, with a heavy sea breaking over Drunken Dick Shoal. Time, about half-tide.

1st. Middle of Beach Channel on Sullivan's Island range lights; direction of current toward lowered portion of jetty.

2d. Opposite Murray's; direction of current toward opening between Drunken Dick Shoal and jetty.

3d. Opposite Steinmeyer's; direction of current toward west end of Drunken Dick Shoal.

4th. Opposite McNulty's; direction of current toward Drunken Dick Shoal, opposite station B.

5th. Opposite station C; direction of current toward Drunken Dick Shoal, opposite Murray's.

6th. At sea-buoy of channel; direction of current toward Drunken Dick Shoal, opposite Steinmeyer's.

It was also observed during the first quarter of the flood-tide that the current passing between Drunken Dick Shoal and the end of the jetty was directed toward Fort Sumter, with a slight eddy on the west side of the jetty. Later its direction was west by north, and the eddy to the west of the jetty was increased till about half-tide, when it was decreased by the flow of the water over the lowered portion of the jetty.

After the first quarter of the ebb, the current became very rapid and strong around the end of the jetty and Drunken Dick Shoal. At a distance of from 50 to 75 feet from the end of the jetty, this current is divided. That portion nearest the jetty passes inside the shoal and forms an eddy in the rear of the former, while that portion beyond this distance passes to the south of the shoal.

These strong currents continued till near low-water.

It was also observed that during the last half of the ebb and first half of the flood there was so strong a current passing over the shoal in front of Steinmeyer's that even during calm weather the water at this point was very rough. The current on the ebb-tide appeared to be the stronger of the two.

CONCLUSIONS.

From the foregoing observations the following conclusions are drawn:

1st. That the portion of the flood current in Beach Channel from opposite Steinmeyer's house to the jetty, which exists before low-water and continues after high-water, is the result of an eddy, caused by the ebb current, passing along the head of Drunken Dick Shoal and the end of the jetty.

2d. That the flood-tide enters Beach Channel before it does the Swash Channel, and that in passing through Beach Channel a large portion of it escapes across Drunken Dick Shoal, from opposite Steinmeyer's to the western end of the shoal. The general direction of the current of this tide is toward Fort Sumter, near which the observations show that the flood current is felt before it appears in the Swash Channel.

Further observations may show that the direction of this current near Fort Sumter is partially due to an eddy created by the fort and the shoal about it.

3d. That the greater portion of the ebb which passes along the shore of Sullivan's Island is deflected by the jetty outside of Drunken Dick Shoal, and that a large proportion of the deflected ebb crosses this shoal into Beach Channel between its western end and opposite Steinmeyer's house.

From these conclusions it will at once be seen that the narrow channel from opposite Steinmeyer's house to the jetty is the result of the escape of the large portion of both the flood and ebb tides across Drunken Dick Shoal from this point to the jetty, and that any project looking to the improvement of this channel must contemplate confining these tidal currents to the Beach Channel throughout its extent.

The narrowest part of this channel is at the extreme western end of the shoal, where it is now but 75 feet wide between the 9-feet curves where a little more than a year ago it was 200 feet wide and 13 feet deep and again in June last it was reported to be 14 feet at low-water.

This diminution of width is the result of the movement of Drunken Dick Shoal, while the shoaling has undoubtedly been influenced greatly by the southeast winds which cause a heavy sea to break along the crest of Drunken Dick.

At or near high-water these seas often pass entirely over this shoal and break upon the beach beyond.

South and southeasterly winds have prevailed in a great degree since July 1.

It was intended to ascertain what action, if any, the westerly winds had on the currents about the head of the jetty, but during the time taken for the survey there were none of sufficient strength to have any effect.

To confine the tidal currents passing through the outer or sea end of Beach Channel, or such portion of them as will give an available channel for commerce throughout its extent, it will be necessary, in my estimation, to use some artificial means in connection with dredging to deflect the ebb-tide which now passes to the south of the head of Drunken Dick, and afterward crosses this shoal, into Beach Channel.

The action of this current would be to give an increased channel-way through what is now the shoalest and narrowest portion of the channel by removing the bulk-head now formed by the flood-tide near the jetty. The removal of this bulk-head would also increase the flow of the flood current through this portion of the channel.

For this purpose I would respectfully suggest a jetty made of palmetto cribs properly weighted with stone ballast.

The outer or western portion of this jetty should extend from the south side of the western end of Drunken Dick Shoal to the submerged outer end of the Bowman jetty.

The outer end in this way would be protected, in a great measure, from the undermining influences of the eddy currents on the ebb and flood tides.

This would give an opening between the two jetties of 500 feet in width.

The length and direction of the eastern portion of this jetty should be determined by the results obtained from the construction of its western end.

In this manner I believe the whole of the western end of Drunken Dick Shoal could be removed and a constant channel of sufficient size obtained, without endangering the channel by an increase of flow on the ebb beyond what there is at present through its eastern end.

This jetty would also break the force of the southeast seas, which now tend to fill up this channel.

Soundings taken from opposite station C to the sea-buoy of Beach Channel, and from there to deep water in a southeasterly direction, show the same depth of water as given on the Coast Survey chart of 1870.

For the protection of the jetty I would also suggest the construction of short perpendicular wings at intervals along its sides to create eddies and cause a deposit of sand at its base.

The further lowering of the Bowman jetty to 16 feet, mean low-water, seems to me to be inadvisable, as the action of the currents has already caused the western end of Drunken Dick Shoal to move to the north as fast as the jetty was lowered, and it is probable that this would continue should a greater portion of the jetty be lowered.

Very respectfully, your obedient servant,

JAS. C. POST,
Captain Engineers.

Lieut. Col. Q. A. GILLMORE,
Corps of Engineers, U. S. A.

COMMERCIAL STATISTICS.

CHARLESTON CHAMBER OF COMMERCE,
Charleston, S. C., June 12, 1878.

SIR: In reply to your communication of the 27th ultimo, with copy of the act of Congress approved July 27, 1868, and requesting such information as I can supply, tending to show to what extent the general commerce of the country will be promoted by the contemplated works of improvement at the entrance of this harbor, with a view to answer the requirements of said act, I beg leave to say that it may safely be assumed that whatever tends to advance the commercial interests and prosperity of the port of Charleston increases the resources and revenue of the country, tends to the promotion of the general good, and subserves the commercial and navigation interests of the United States.

The large vested interests of the citizens of Charleston in wharves, warehouses, banks, railroads, and other property, contingent and dependent upon the commerce of that port, requires the same protection as is given by government to other cities, through works of improvement to their harbors, whereby large vessels suited to her trade can enter and depart in safety.

A greater depth of water is required over the bar at this harbor to admit the largest class of merchant steamers and sailing-vessels to load with heavy cargoes of cotton, naval stores, phosphate rock, as well as grain and other produce of the Western States, for Europe. Vessels of a larger class and drawing more water than can now enter the port are required for the trade, and such vessels can be sailed with greater economy in proportion to their tonnage, than smaller vessels.

Deep water, such as is required at Charleston, is regarded as a commercial necessity. Unless it be secured here, and at other ports requiring like assistance, efforts will be made to build up new ports which have no claim or advantage except depth of water. About $30,000,000 are invested in Charleston for the accommodation of trade and commerce. This will be promoted and enhanced in value if the proposed works be carried out. If not, it will be impaired in value, and many millions of dollars will be needed to give new ports the facilities Charleston already possesses. In other words, the expenditure of less than $2,000,000 will save $30,000,000 now in existence, and avoid the supposed necessity to invest many more in wharves, warehouses, &c., at some deep-water port.

The report of the United States Board of Engineers upon the project of General Gillmore for the permanent improvement of the ship-channel at the entrance of Charleston Harbor, and in which report General Humphreys, the Chief of Engineers, fully concurs, sets forth "that the channel over the bar can be improved to a probable depth of 21 feet at mean low-water by the use of jetties submerged in whole or in part." The greatest depth of water over the deepest channel into the harbor is from 12 to 13 feet at mean low tide, and the proposed improvement, which is deemed entirely practicable by the highest engineering authority, both civil and military, will enable ships drawing 25 to 26 feet of water to cross the bar in perfect safety at ordinary high tides. This depth of water is all that is required to insure to Charleston those advantages of trade and commerce to which her geographical position entitles her, and which her present wants and future prospects seem to demand.

* * * * * * *

We are not envious of our sister cities of the South or elsewhere; we are glad to see them prosper, and congratulate them on their enterprise and influence in the national councils, but the records of Congress will show how much the commercial interests of this city and of the country naturally tributary to it have been neglected by the general government. The State of South Carolina has expended $200,000 for the improvement of Charleston Harbor, being more than has been appropriated by the general government for that purpose since the adoption of the Federal Constitution, not one dollar of which has been refunded to the State. The city of Charleston has also expended from its treasury over $25,000 for the same purpose, without any return from government.

The proposed improvements to Charleston Harbor would give to the country an Atlantic port easy of access, amply commodious, and perfectly safe for shipping in time of peace, and equally easy of defense in time of war against the greatest maritime powers.

I would further state that by a railroad now under construction our system of railroads will soon be more closely connected with that of the West and Northwest, and will offer to the grain-growers of that section the shortest, cheapest, and most reliable route by which to send their productions to European, South American, and West Indian markets. This route will shorten the distance from Cincinnati to the Atlantic by about 200 miles. It will cost less to construct than any other road crossing the Blue Ridge and Alleghanies, and will throughout most of its length be free from the obstructions which in winter cause so much annoyance, delay, and expense over roads leading to more northern cities. It needs but the assurance of deep water on our bar to insure the speedy completion of this route, which has another strong claim on the fostering care of the general government, which is, that in the event of war with any of the great powers of Europe it would offer a perfectly secure and direct line of communication between the Northwest, South, and Southeast, protected as it would be by impassable mountain ranges through the greater part of its course.

It was mainly from a knowledge of the advantages to result to Charleston and the country at large that the Chamber of Commerce in March, 1828, through its committee of inquiry, reported in favor of the construction of the present South Carolina Railroad, with a view to other railroad extensions to the West. In the same year, upon application to the United States Engineer Department, Col. William Howard, United States civil engineer, with a competent corps of assistants, was detached to examine and report upon the proposed railroad. In January, 1829, Colonel Howard made his preliminary report, in which he urges "the benefits to result from the extension of this road to the Tennessee River, and through it to the fertile regions of the West." This extension, he continues, should be kept steadily in view to its ultimate accomplishment; and further, that the amount of trade will serve "to animate the district of country through which the road will pass, and restore the commercial capital of the State to far more than its former prosperity."

There was a period in the early part of this century when Charleston was one of the largest commercial cities of the Union, equaling or surpassing in population and the value of her exports nearly all of the Atlantic and Gulf ports. At that period the vessels engaged in the foreign and coastwise trade of the country were of light draught, and the depth of water over our bar was amply sufficient to admit the largest merchantmen of the times.

In later years, when vessels of greater size and draught of water were built, those ports whose harbors were unobstructed by shoals, or which have been improved by government expenditure, and could admit this larger class of vessels, drew off a great part of the export trade which should have come to Charleston, and have been in that way built up partly at our expense. We cannot hope to recover all of this lost trade, but we ask only in justice to be placed upon a fairer footing with our competitors by reasonable harbor improvements, so that in the future we may hold our own and share in the natural increase of the commerce of the country.

I have the honor to be, very respectfully, your obedient servant,

S. Y. TUPPER,
President Charleston Chamber of Commerce.

Bvt. Maj. Gen. Q. A. GILLMORE,
Lieutenant-Colonel of Engineers, U. S. A.

Entrances and clearances of vessels at the custom-house, port of Charleston, S. C., from 1873 to 1877 inclusive.

VESSELS ENTERED.

Year.	Coastwise.			American vessels from foreign ports.			Foreign vessels from foreign ports.			Total.		
	Number of vessels.*	Tonnage.	Crew.	Number of vessels.	Tonnage.	Crew.	Number of vessels.	Tonnage.	Crew.	Number of vessels.	Tonnage.	Crew.
1873	463	349, 602	10, 245	57	13, 067	414	80	34, 973	1, 015	600	397, 642	11, 674
1874	510	372, 378	11, 467	45	11, 484	355	174	77, 940	2, 198	729	461, 802	14, 020
1875	504	382, 018	11, 649	38	13, 144	326	198	88, 879	2, 404	740	484, 041	14, 379
1876	471	340, 439	10, 113	44	11, 898	335	224	101, 272	2, 768	739	453, 609	13, 216
1877	400	324, 919	9, 885	32	13, 972	308	236	105, 480	2, 851	668	444, 371	13, 044

VESSELS CLEARED.

1873	400	290, 950	9, 189	56	17, 678	481	97	47, 822	1, 250	553	356, 450	10, 920
1874	409	318, 619	10, 148	52	18, 236	473	192	84, 205	2, 335	653	421, 060	12, 956
1875	461	328, 266	10, 830	57	24, 679	555	211	94, 595	2, 527	729	447, 540	13, 912
1876	431	278, 744	9, 095	60	23, 598	546	230	103, 276	2, 812	721	405, 618	12, 453
1877	335	234, 429	7, 719	35	22, 767	423	250	108, 446	2, 910	620	365, 662	11, 052

Year.	Value of exports.	Value of imports.	Import duties collected.
1873	$14, 350, 041	$746, 139	$152, 759
1874	17, 900, 146	803, 573	164, 107
1875	19, 655, 966	680, 343	80, 656
1876	18, 088, 152	455, 562	89, 168
1877	16, 917, 492	161, 237	46, 848

*The above only exhibits the number of vessels in the coastwise trade that are required by law to enter and clear at the custom-house. A large number of vessels arrive and depart which are not required to so enter and clear.

SPECIAL REPORT ON PERMANENT IMPROVEMENT OF THE CHANNEL OF ENTRANCE INTO CHARLESTON HARBOR, SOUTH CAROLINA.

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., May 3, 1878.

SIR: I beg leave to return herewith the resolution of the Senate of the 25th April, 1878, viz—

That the Secretary of War be requested to communicate to the Senate any information in his department concerning the practicability and cost of constructing permanent works of improvement for the ship-channel at the entrance into the harbor of Charleston, South Carolina—

referred to this office for report, and, in compliance therewith, to submit

the inclosed copy of a report on the subject recently received from Lieut. Col. Q. A. Gillmore, Corps of Engineers, in which a project for the permanent improvement of the channel of entrance into Charleston Harbor by means of low jetties, with a general estimate of their probable cost, is presented.

A copy of the preliminary report of the Board of Engineers to whom his project was referred for consideration is also submitted.

I concur in the views of the Board—

That the channel over the bar can be improved to a probable depth at mean low-water of 21 feet by the use of jetties, submerged in whole or in part, and by a mode of construction very gradual in its progress, which will admit of such modifications in the lengths and heights of the jetties as experience shall dictate.

I further concur in the view—

That the project adopted should disturb to the least possible degree the present regimen of influx and efflux over the bar.

The Board reports that the estimated cost of the proposed improvement will vary, according to the extent of the project which may be adopted, from $1,800,000 to $3,000,000.

Lieutenant-Colonel Gillmore recommends the annual appropriation of about $500,000 in four successive years, a recommendation in which I concur.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brigadier-General and Chief of Engineers.

Hon. GEO. W. MCCRARY,
Secretary of War.

REPORT OF LIEUTENANT-COLONEL Q. A. GILLMORE, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
New York, March 9, 1878.

GENERAL: I have the honor to submit a project, hereinafter described, for the permanent improvement of the channel of entrance into Charleston Harbor, South Carolina, by means of low jetties, with a general estimate of their probable cost, accompanied by two sheets of drawings, designated respectively as Plate I and Plate II.

THE CHARLESTON BAR.

The bar which stretches bow-shaped across the entrance into Charleston Harbor, from Sullivan's Island on the north to Folly Island on the south side, has not varied much in either location, general direction, or magnitude within the period covered by any trustworthy knowledge which we possess on the subject.

In the year 1852 a commission, composed of Prof. A. D. Bache, Superintendent of the United States Coast Survey; Lieutenants J. N. Maffitt, M. F. Maury, and C. H. Davis, United States Navy; and Lieut. J. D. Kurtz, United States Army, in a report on Charleston Harbor and Bar, made with special reference to works of permanent improvement, stated that a comparison of the chart of 1780, published in Des Barrés' Atlantic Neptune, with those of 1821, 1825, and 1851–'52, "shows that according to the earliest records the bar of Charleston has varied comparatively

but little in extent, direction, or in distance from the mouth of the harbor."

Measured along its crest, or line of least depths, the bar is ten miles in length, its north end on Sullivan's Island being close up to the entrance or throat of the harbor, while its south end, resting on Folly Island, is six miles distant therefrom. Its average width between the 18-foot curves is about $1\frac{3}{4}$ miles.

In many places the highest points of the bar are only 3 to 4 feet below the level of mean low-water, although the average depths along the crest are considerably greater.

The main central body of the bar, lying near due north and south, is nearly straight for a length of over five miles, has its crest parallel to the main shore south of the entrance and at a mean distance of about two miles from it, and is not at the present time, and, so far as we know, never has been traversed by practicable ship-channels.

The northern and southern extremities of the bar are formed by rather sharp curves, which connect the straight portion already mentioned with the shore above and below the harbor.

So far as we can now ascertain there appear never to have been less than four nor more than six ship-channels across the bar at any one time. The greatest depth of water has sometimes been found in one channel and sometimes in another, being rarely less than 12 feet or more than $13\frac{1}{2}$ feet at mean low tide.

The channels, whether four or more, have always existed in two groups or clusters, one in the northern and the other in the southern curved portion of the bar, and there has always been a deep and broad anchorage inside the straight reach of the bar abreast of Morris Island.

This anchorage, sometimes called the "main channel" and sometimes the "outer harbor," varies in width from one-third to two-thirds of a mile between the 18-foot curves, and in maximum low-water depths from 20 to 45 feet. The direction of its central line is about north and south, and its length from the throat of the harbor between Morris and Sullivan's Islands to its southern terminus, where it spreads out in various channels and shoals in crossing the bar, is fully five miles. At the extremities of this outer harbor or basin, several miles apart, are found the two groups of channels already mentioned, the most northerly group being directly in front of the gorge of the harbor.

The bar is essentially a drift-and-wave bar, produced in part by the upheaving action of the waves when they approach the shore, and are converted by breaking into waves of translation, and in part by drift-material carried along the coast by surf-currents, especially by those produced by northeast storms. The peculiar location of the bar, largely to the southward of the gorge of the harbor, and the conditions under which a very large proportion of the ebb-flow is diverted from its most direct path, and forced to skirt the main coast for several miles before it can find a passage to the sea, indicate the controlling power of these storms.

The material composing the surface of the bar closely resembles that usually found on the sea-shore between high and low water in that section of the country, being shells and fragments of shells, or siliceous sand, or a mixture of them all. It is easily thrown into suspension by waves, and is moved by a moderate current.

On the north end of the bar five borings were made in order to determine the character of the substrata. The points selected for boring, and the results obtained, are indicated on the accompanying drawings.

It will be seen that below the surface there are some layers or lumps of mud, as well as of mud mixed with sand, and mud mixed with shells.

All the channels which traverse the bar are, and, so far as we know, always have been, ebb-tide channels, produced and maintained by the scour of the ebb-current, except Beach (formerly Maffitt's) Channel, the most northerly of them all, which lies close to Sullivan's Island. This is a flood-tide channel, possessing the usual characteristic of such channels, that their least depths are always found near their inner ends, and therefore in comparatively quiet water. Another distinguishing feature of such channels is that from the cross-section of shoalest soundings inward, toward the harbor, the descent into deep water is sharp and sudden, while outward, toward the ocean, it is gradual and gentle.

The North or Cumberland Channel at the entrance into Cumberland Sound, Georgia, and the Coney Island Channel of New York Harbor are of the same character.

In speaking of the preponderance of the flood over the ebb in Cumberland Channel, in my report on the jetty system as applied to the entrance into Cumberland Sound, Georgia, submitted April 15, 1876, I say:

> The effect is to make the inner slope of this part of the bar very steep: the sand which is rolled along by the flood-current on the bottom of the outer slope is first broght to rest in the deep water of the inner basin. The ensuing ebb-current, which receives its velocity and direction from the large volume of Cumberland Sound, sweeps the inner slope of the nothern shoals longitudinally, and takes up this sand and carries it out by the Amelia Basin, depositing it upon the main bar. The channel next to Cumberland Island is therefore a flood-tide channel, like the Sullivan's Island or Beach Channel in Charleston Harbor. They both possess in a marked degree the steep inner slope which invariably characterizes a channel maintained by the flood-tide, which having once passed in is so much diverted in its direction on the ebb, by the axial line of the tidal basin, that it cannot flow out in full volume through the same opening, but sweeps past its mouth in its passage to some more direct outlet.

Beach Channel was gauged during the months of May and June, 1876, when it was found that on a section taken 500 yards east of the inner end of the channel, at the Bowman jetty, the volume flowing out during an entire ebb between the low-water line on Sullivan's Island and the 5-foot curve on Drunken Dick Shoal, amounted to only 48.8 per cent. of the volume flowing in during an entire flood through the same section.

On a section taken 930 yards east of the Bowman jetty, between the low-water line on Sullivan's Island and the 10-foot curve on Drunken Dick, the volume of ebb amounted to 52½ per cent. of the flood.

The following table shows the mean low-water depths in the several channels across the Charleston Bar since 1821, taken from Coast Survey charts and other sources of information at command. Within that period Beach Channel has not changed at all in location or direction, except very slighly at the "bulkhead," due to the shortening of the jetty. From 1856 to 1870 there was very little change in either the general direction or position of the North or Swash Channels. Between 1856 and 1870 both the Pumpkin Hill Channel and the main ship-chan-

nel moved about half a mile to the southward, and the Lawford Channel disappeared entirely.

	Date of chart or survey.	Least depth at mean low-water in—					
		Beach or Maffitt's Channel.	North Channel.	Swash Channel.	Pumpkin Hill Channel.	Main ship-channel.	Lawford Channel.
		Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Lieutenant Sherburne, U. S. N	1821	6	.....	.....	.....	11	10
United States Coast Survey	1850	7	8	.....	.....	.....	.....
Do	1852	8	8	8	.....	10.6	8
Do	1854	10.25	.....	.....	.....	.....	.....
Do	1855	11	.....	.....	.....	.....	.....
Do	1856	*11	*8	*9	†12	†11	*7
Captain Cullum, United States Engineers	1857	12	.....	.....	.....	.....	.....
United States Coast Survey	1858	*11	*8	*9	†12	†11	*7
Do	1866	†12	shoaled	†12	12	†12	shoaled
Do	1870	†12	†9½–10	†12.5	11	†13	...do..
‡Captain Ludlow, United States Engineers	1871	11	.....	.....	12	.....	.....
‡Captain Post, United States Engineers	1877	11	.....	.....	.....	.....	.....

* Least depth given by sailing directions on chart.
† Least depth shown in channel on chart.
‡ Under direction of Lieut. Col. Q. A. Gilmore, United States Engineers.

NOTE.—In February, 1875, there was a narrow channel in Beach Channel of 14 feet depth at mean low water, with 11-foot lumps.

CAPACITY OF THE TIDAL BASIN.

The area of the tidal basin formed by Charleston Harbor, as computed from the Coast Survey chart and Mills's Atlas of South Carolina, is about 15 square miles. This area is assumed to be filled during each mean flood-tide by a layer or prism of water 5.1 feet in height above the mean low-water level. In addition to this the adjacent reaches of the tributary rivers will be filled above their low-water stage by flood and back waters, which at the period of slack-water flood will form in each stream a wedge-shaped mass resting on the sloping low-water line of the river, and extending up to a point where the influence of the tidal wave ceases to produce a rise and fall of the surface of the water. The lower portions of these wedge-shaped masses will flow out through the gorge of the harbor on each ebb-tide.

From these data it is estimated that the average discharge through the throat of the harbor between Sullivan's and Morris Islands, on each ebb during the period of mean rise and fall of tides, amounts to a little over 3,655,443,686 cubic feet. Of this volume only about 76,571,000 cubic feet is supplied by the land drainage, on the assumption that one-half the rain-fall reaches the sea. This estimate is believed to be not too large, in view of the fact that the streams are short and in close proximity to the points of discharge.

For two or three days during the period of spring-tides, the average ebb-discharge will be augmented to about 4,228,846,000 cubic feet.

The neap discharges, being in smaller volumes than those pertaining to mean tides, require no special mention, as any temporary decrease of scouring power in the new channel beyond the jetties resulting therefrom would be of short duration. Even if slight shoaling ensued during this period, the maximum depths established by mean and spring tides would be restored on the return of these tides.

The mean duration of the ebb-flow is taken at 6 hours, that being the

average of a number of observations taken by Civil Assistant George Daubeny, in 1870 and 1871, the longest flow being $6^h\ 20^m$, and the shortest $5^h\ 25^m$.

The average ebb-discharge per second through the gorge of the harbor during the period of mean rise and fall of tides is therefore 169,233 cubic feet ($\frac{3655443686}{21600}$), and during the period of spring-tides 195,780 cubic feet ($\frac{4228846000}{21600}$), the average rise and fall at ordinary spring-tides being 5.9 feet. No account is here taken of the somewhat longer duration of ebb flow at average spring-tides.

During very high spring-tides the discharge will be much larger.

With a rise and fall of 10.3 feet (which has actually occurred), the prism amounts to about 7,382,562,000 cubic feet, equivalent to 341,780 cubic feet per second; nor will this show the total discharge, since the marshes will be flooded, and their area being estimated at 8 square miles, every layer of water over them 3 inches thick will add 55,965,870 cubic feet to the prism, or 2,590 cubic feet to the average discharge per second.

It has not been deemed expedient, or likely to give trustworthy results, to attempt to gauge the flow through the gorge of the harbor by means of current-velocities. Those taken some years ago between Forts Sumter and Moultrie, with a view of locating channel torpedoes, proved the existence of eddies and counter-currents, and other irregularities of flow, to such degree, especially near the Sullivan's Island side, that the requisite accuracy seemed hardly obtainable by this method.

There is nothing specially exceptional in this, for it is known that abnormal conditions often characterize the flow of water through the gorge of a large tidal basin.

It is stated by Mr. D. Stevenson that at Cromarty Firth, where the waters pass to and from the sea through a narrow gorge, of which the width is about 4,500 feet and the depth about 150 feet:

> The mean velocity due to the column of water passing this gorge, as deduced from the observed surface-velocity, was not sufficient to account for the quantity of water actually passed during each tide, as determined by measuring the cubical capacity of the basin of the Firth. This led to the observation of the undercurrents through the gorge by means of submerged floats, and it was found that during flood-tides the surface-velocity was 1.8 miles per hour, while at the depth of 50 feet the velocity was not less than 4 miles per hour, being an increase of 2.3 miles per hour. During the ebb-tide the surface-velocity was 2.7 miles per hour, and at 50 feet depth it was not less than 4.5 miles per hour, being an increase of 1.8 miles per hour.

Anomalous variations and irregularities between the surface and the subcurrent have also been found to exist in the harbor of San Francisco, Cal., and elsewhere.

For the foregoing reasons, mainly, it has been thought best to use the cubical capacity of the tidal basin and the rain-fall upon the drainage-area in estimating the average volume of water which flows out and in through the gorge of Charleston Harbor.

PLAN OF IMPROVEMENT RECOMMENDED.

It is proposed to construct two jetties, one springing from Morris Island and the other from Sullivan's Island, converging toward each other in such manner that their outer ends on the crest of the bar shall be one-half to five-eighths of a mile apart. The outer ends of the two jetties will rest respectively upon the shoals lying to the northward and southward of what is known as the north channel, that being the middle channel of the north group of three channels, and having its line of deepest water located more nearly than either of the others upon the

prolongation of the axis of deep-water flow through the gorge of the harbor between Cumming's Point and Fort Moultrie.

Assuming for the purposes of discussion the sea ends of the jetties to rest respectively at X and Y, it seems, in some measure, immaterial whether they be established upon straight lines, as shown at AX′and BY, Plate I, or upon curved lines; and if curved, whether the convexity be turned toward the central channel, as at CX and DY, or from it, as at EX and FY. In either case, if kept at the proper heights, they will produce an ebb-flow through the gap able to maintain a deep channel through the bar. Neither the straight jetties, however, nor more especially those with their convexity turned away from the channel, act as training-walls to guide the outflowing water. The curved jetties, convex toward each other, being less open to this objection are the ones adopted in this project.

The north jetty starts from a point on Sullivan's Island, 1,800 yards east of Bowman's jetty. The half next the shore is curved to a radius of about 1½ miles, the outer half being very nearly a straight line. The total length of this jetty from C to X is 7,450 feet, and its general direction is southeast.

The south jetty, having a total length of 11,650 feet from D to Y, starts from Morris Island at a point about 650 yards from Cumming's Point, its general direction being east. The shore end is curved to a radius of about 3 miles for a little more than one-half its entire length, while the half next the sea is nearly straight, as in the case of the north jetty.

The specified length of the jetties is taken for purposes of discussion. As will be seen hereafter, they would not be able to produce a channel of the requisite capacity through certain materials which may be encountered in the bar, although they would be expected to maintain such a channel if once established.

The outer ends of the two jetties slightly converge toward each other as they approach the crest of the bar, and are intended to act as training-walls for a distance, in each case, quite equal to half its entire length. These portions lie in the direction of the flood-currents, and may be built to any height without obstructing the inflow. For fully one-fourth of their entire length the sea ends could be carried above the level of high-water, so as to be visible at all stages of the tide. The inner portions, crossing the Beach and main channels, respectively, might perhaps be kept low enough to allow the smaller classes of vessels to pass over them.

One characteristic feature of the design, that of low jetties, is intended to maintain the bar in its present general location, with such moderate increase of magnitude as may be expected to result from concentrating upon a gap one-half to five-eighths of a mile in width a portion of the water which is now dispersed over a width of 10 miles.

The complete success of the works is believed to depend on three important conditions, which they are expected in great measure to satisfy, and which have been kept in view in preparing the design, viz:

1. *They should not impede the inflow to such degree as to prevent the tidal basin being filled as now at every influx of the tidal wave.*

To this end the inner half of each jetty, more especially its central portion, located in deep water across the thread of the current, is kept several feet below the water. The outer half, being nearly parallel to the direction of the flow, is built higher, and the sea end, for a distance of several hundred feet, may be carried high enough to be visible at all stages of the tide.

2. *They should control the outflow to such degree and in such manner that a channel of the required depth will be maintained through the bar.*

To this end, although a large portion of the *surface flow* will spread out over the tops of the jetties and thence over the bar, the *central flow*, throughout the entire depth along the axial line of the gorge between Sullivan's and Morris Islands, is aided in its natural tendency to reach the sea along the prolongation of that line by the opening left for it between the jetties. The *bottom flow* through the gorge of the harbor is deflected on converging lines by the jetties, and is therefore forced in a measure to concentrate itself in, and flow out through, the gap between them. The outer half of each jetty and the adjacent portion of the shore end act as a training-wall for this flow.

3. *They should not to any considerable extent cause a morement seaward of the main body of the bar; that is, the general position of the bar should be independent of the effects produced between and beyond the heads of the jetties.*

It is believed that this condition will be secured by making the shore ends of the jetties low for at least one-half their length, or throughout those portions which cross the thread of the current in deep water, so as to allow the tide to ebb and flow somewhat freely over them. The effect of high jetties, with a correspondingly wide gap between them to allow a full influx of the tide, would tend to transfer the gorge of the harbor from its present position to the sea ends of the jetties and move the shore line out to that point, by causing a filling in of the exterior angles between the jetties and the shore. After reaching this stage, a drift-and-wave bar would probably be found to the seaward of the present bar, in front of the jetties, rendering it necessary to extend them in order to cut a passage through it.

It seems essential, therefore, that the agencies which maintain the present bar should remain in as full force as possible, consistent with the requisite concentration of outflow between the jetties.

The probable effects will be that the bar will be raised somewhat throughout its entire length, the waves will break upon it more frequently than now, and considerable shoaling will, of course, take place in Beach Channel and in all the southern group of channels. But it is believed that the important condition of keeping the bar generally in its present position will be secured.

The drift-material carried along the coast by surf-currents, as well as the sand thrown up by the breakers on the north and south shoals, instead of lodging in and filling up the exterior angles between the jetties and the shore, as in the case of high jetties, will be disposed of in a harmless manner.

For example, a heavy northeasterly storm, producing breakers along the north shoal and strong southerly surf-currents along the shores of Long and Sullivan's Islands, would put in motion a large quantity of material, a portion of which would be carried in by the flood-currents over the north jetty and through Beach Channel, coming to rest in the deep water of the main channel. It would next be taken up by the ebb-current and rolled out to sea between the jetties. Beyond the jetty-heads it would encounter the littoral ebb-current, moving to the southward with a velocity accelerated by the storm, by which it would be again carried in a southwesterly direction, until finally, left to the action of the south breakers, it would be either deposited temporarily upon the south shoal or carried still farther to the southward. This action, which would be incessant during the continuance of the storm, is illustrated in Figure 1, Plate II.

The action of a southerly storm would be the reverse of this. In either case some drift-material would be carried by waves and surf-currents around the jetty-heads, and would subside in the deep water between them, to be swept out by ensuing ebb-currents, and disposed of to the northward or southward, according to the direction of the storm.

This movement of sand was referred to in my report on the improvement of the Fernandina Bar, submitted April 15, 1876, from which the following extract is made:

> As a moderate assumption, a northeaster of three days' duration might be expected to lower the north shoal 4 inches within the area covered by the breakers. The greater part of the eroded material, amounting to upward of 516,000 cubic yards, would doubtless be distributed along the south shoal during the progress of the storm. If the waves should subside or a southerly or southeasterly storm set in before the bar channel had returned to its normal condition, the material subsequently carried out would not reach the south shoal, but in the former case would remain near the outlet on the outer slope of the bar, and in the latter would be carried back by the waves to the north shoal. If as much as one-fourth of it remained in the bar channel between the inner and outer 18-foot curves, a few severe storms, such as frequently occur within the period of a single month, would entirely destroy it, by filling it up to the level of the shoal on either side.
>
> It would appear, therefore, that millions of cubic yards of the material composing the bar might be shifted back and forth from one side of the channel outlet to the other during a single season, without causing injury to the channel by shoaling, and without producing any changes in the form and location of the bar itself that might not entirely escape the notice of the most careful surveyor. And yet this shifting of material of which no evidence may be left behind should enter as an important, if not a controlling, function in the project of the engineer, because the useful life of his works is more or less dependent thereon.

As no works can be expected to stop this movement of drift-material for any great length of time, they should, if practicable, accommodate themselves to it under conditions of a permanent character. Those proposed are designed to do this, by allowing the drift-sand to move from one part of the bar to the other in much the same manner as now, never remaining in the jetty channel longer than a few tides, and never finding a resting-place anywhere that the next storm may not disturb.

PROBABLE EFFECT PRODUCED BY THE JETTIES.

An attempt is made below to determine by the use of appropriate formulæ the principal phenomena of the ebb-flow, after the jetties shall have been constructed and an enlarged water-way of the greatest self-maintaining area has been established between them and the hydraulic equilibrium has been restored.

The jetties in this discussion are first assumed to occupy the lines CX and DY, Plate I, with their respective crests established at the varying heights shown by the longitudinal sections CX and DY on Plate II, the sea ends being half a mile apart.

The north jetty crosses the deep water of Beach Channel at the level of 12 feet below mean low-water, the crest being held at that level for a length of 650 feet, whence it rises gradually by a series of gentle slopes to high-water at each end. On the sea end the part carried to high-water level is 1,500 feet long.

The south jetty, designed on a similar plan, crosses the main channel on a level 15 feet below mean low-water, the seaward end for a length of 2,000 feet having its crest at high-water.

The sectional area of the gorge profile between Cumming's Point and Sullivan's Island is as follows:

	Square feet.
Area of low-water section	159,550
Area of high-water section	195,350
Mean ebb-tide area	176,600

The width of the surface at half-tide, corresponding to the mean ebb-tide area, is 6,825 feet, and the wetted perimeter 6,927 feet. The hydraulic radius is, therefore, 25.46 feet.

At mean low-water the surface width is 6,750 feet, the wetted perimeter 6,851 feet, and the hydraulic radius 22.29 feet.

The area inclosed between the line of gorge at Cumming's Point and that of the proposed jetties and gap is 2.16 square miles.

The average discharge per second across the sites of the jetties and through the gap between them is, therefore, 183,451 cubic feet $\left(\frac{3,655,443,886 + 307,108,434}{21,600}\right)$ or 14,218 cubic feet more than the amount flowing out at the gorge.

The following are the sectional areas in square feet now existing on the lines proposed for the jetties and gap:

	Low water.	Mean half tide.
	Square feet.	*Square feet.*
Line of north jetty	59,900	78,880
Line of south jetty	171,720	201,365
Gap	22,840	29,572
Totals	254,460	309,817

For the following calculations the D'Aubuisson Downing formula will be used, not because it is the best, but mainly because it is very simple and easy of application. It is, moreover, believed to answer very well in cases of broad open streams.

The formula is—

$V = 100 \times \sqrt{s} \times \sqrt{r}$, in which
V = velocity in feet per second.
s = slope, or ratio of horizontal length to vertical descent.
r = hydraulic radius in feet.

In the gorge at Cumming's Point the grand mean of all the velocities is .958 feet per second $\left(\frac{169,233}{176,600}\right)$.

The grand mean of all the velocities with which the water passes through the various compartments of the present section along the line of the jetties and gap is 0.59212 feet per second $\left(\frac{183,451}{309,817}\right)$.

The mean hydraulic ra ius of this aggregate section is 14.0322 feet $\left(\frac{309,817}{7,574.3 + 2,679.7 + 11,825}\right)$.

Therefore $V = 0.59212 = 100\sqrt{14.0322} \times \sqrt{s}$.

$$\sqrt{s} = \frac{0.59212}{100 \times \sqrt{14.0322}} = 0.0015807$$

$$S = 0.0000024980.$$

On the assumption that this slope is the same throughout the section which in point of fact is not precisely the case, and we have no data

for making the necessary correction for the several compartments), the total average volume of discharge per second, amounting to 183,451 cubic feet, is distributed as follows, as determined by the various areas and hydraulic radii:

	Cubic feet.
Through present section on site of north jetty	39,418
Through present section on gap	15,227
Through present section on site of south jetty	128,806
Total as above	183,451

This must be assumed to represent the present distribution of the outflow per second through the section selected for the sites of the works and the opening between them at its narrowest point.

The changes of regimen which the jetties will tend to produce, and the area of the water-way which, once established, they would be expected to maintain between and beyond the sea ends, will next be considered.

The north jetty will reduce the half-tide area of the water-way from its present area of 78,880 square feet to 41,593 square feet, and the hydraulic radius from 10.41 feet to 7.59 feet.

The south jetty half-tide water-way will be reduced from the present area of 201,365 square feet to an area of 94,684 square feet, and its hydraulic radius from 17.03 feet to 10.77 feet.

These hydraulic radii are to be considered permanent, the crests of the jetties being supposed to be able to resist abrasion by the current.

In the gap, where alone erosion can take place, the present mean half-tide water-way is 29,572 square feet, and the mean low-tide area 22,840 square feet.

After the jetties shall have received their maximum scour, aided by dredging or other artificial appliances wherever clay-beds are encountered and the equilibrium of flow is resumed, the original general average slope $S=0.000002498$ will be restored.

The aggregate average discharge per second before the jetties were built will also be restored.

From these premises the following average discharges per second are found:

	Cubic feet.
Across crest of north jetty	18,113
Across crest of south jetty	49,110
Total over the jetties	67,223

The balance of the discharge, amounting to 116,228 cubic feet per second (183,451—67,223), will go out through the gap between the jetties, where at present there is a mean half-tide area of only 29,572 square feet and a mean discharge of 15,227 cubic feet per second.

The formula already used gives for the average velocity through the gap:

$$V=100\times\sqrt{s}\times\sqrt{r}$$

Substituting the value $\sqrt{s}=0.0015807$, we have

$$V=0.15807\times\sqrt{r}$$

The value of r is unknown. The width of the gap being 2,640 feet, we have for the wetted perimeter, by General Abbot's rule, 2,680 feet ($2{,}640\times1.015$).

If A represent the unknown half-tide area of the gap in square feet, we have

$$r=\frac{A}{2{,}680}$$

and

$$r=0.15807\times\frac{\sqrt{A}}{\sqrt{2680}}$$

The calculated average discharge through the gap per second being 116,228 cubic feet, we have

$$116{,}228=A\,r=A\times\sqrt{A}\times\frac{0.15807}{\sqrt{2680}}$$

$$A=\frac{\sqrt[3]{(116{,}228\times\sqrt{2680})^2}}{0.15807}$$

$$A=113{,}160 \text{ square feet.}$$

The mean hydraulic radius at the gap will therefore be 42.22 feet $\left(\frac{113{,}160}{2680}\right)$ at mean half-tide, or 39.71 at mean low-water. This implies very considerable mid-channel depths.

In the profile between Fort Sumter and Sullivan's Island, having a mean low-water area of 177,620 square feet, a width of 4,960 feet, and a hydraulic radius of 35.28 feet, fully 90 per cent. of the total area pertains to depths of 24 feet and upward, occupying a width of 3,540 feet, in which the maximum depth is 76 feet.

On the profile from Cumming's Point to the Bowman jetty, the low-water area is 159,550 square feet, the width 6,750 feet, and the hydraulic radius 23.29 feet. The compartments of 24 feet depth or more form 80 per cent. of the whole section, and occupy a width of 3,000 feet, with maximum depths close up to 70 feet.

In the new channel between the jetty-heads, where the hydraulic radius is 39.71 feet, it may be expected that the area of depths of more than 24 feet will constitute a very large proportion of the total area of the gap, and that maximum depths of 75 feet and upward would be maintained in mid-channel.

The average velocity from which the general average slope is derived is, of course, less than the velocity that will prevail in the deep-channel compartments of the profile, since with unaltered slope the velocities in different portions of the profile may be considered to vary as the square root of depths. The grand average velocity in the profile between Cumming's Point and Bowman's jetty, with a mean hydraulic radius at half-tide of 25.46 feet, is .958 feet per second; in the 50-feet compartments the *average* velocity would be 1.33 feet per second; while during the second and third quarters of ebb the velocities will vary between 2 and 3 feet per second.

The bottom velocities will generally be but little less, to judge from the results of a great number of current-observations made near Fort Sumter by Capt. William Ludlow a few years ago.

Of the effects that will be produced to the seaward of the jetties upon the outward slope of the bar by so large a volume of outflow, it is impossible to deduce from formulæ results upon which reliance can be safely placed. We know what kind of effects will ensue, but we have no precise measure of their intensity. The first and greatest difficulty met with is the want of trustworthy data concerning the rate at which the

water, as it issues forth from the gap, will spread out and disperse over the descending outer slope of the bar, with a diminishing velocity and scouring power. For the purpose of discussion, it will be assumed that the currents having passed the jetty-heads will spread out in a fan-shaped area, at an angle of 30 degrees on each side, with the axis of the new channel. The chart seems to indicate that this angle is not too small. It is, however, largely conjectural.

Assuming, however, a total spread of 60 degrees, the width of the profile 1½ miles to seaward, through which the outflow from the jetties is supposed to pass, is 10,933 feet.

By adding the fan-shaped water-prism between the jetty-heads and the seaward profile to the volume of flow through the former, we find that the average volume passing through the outer profile will be 128,916 cubic feet per second.

The half-tide sectional area of the profile is found, by the method of calculation already employed, to be 172,312 square feet. Its wetted perimeter is 11,097 feet, its hydraulic radius at mean half-tide 15.52, and at mean low-water about 13, which implies more than ample mid-channel depths through the outer slope of the bar for vessels of the deepest draught.

As this outer profile is taken upon the seaward slope of the bar a little beyond the 18-foot low-water curve, the permanent depths first secured there—permanent because representing a restored equilibrium—can, of course, be increased at pleasure, and at a small relative cost, by the moderate extension of the jetties.

If the gap between the jetties be widened, the submerged portions must be raised to a greater average height, thus diminishing the area of water-way above them, in order that a channel of the same mean depths in the seaward profile near the outer 18-foot curve, above deduced for a specified height, may be maintained. Considerations of cost furnish strong arguments for keeping the crest of the jetties low, as the expense of added height in jetties with side slopes increases much more rapidly than the height itself. For example, a wall 10 feet high and 10 feet wide on top, with slopes of 45 degrees, contains 200 square feet in cross-section, while a wall of the same width on top and only twice the height contains three times that area of cross-section. By doubling the height the quantity of materials required is therefore trebled in this case, and more must be still added to compensate for the increased subsidence caused by doubling the weight on the foundation. By trebling the height we get six times the area of cross-section.

With an opening between the jetties five-eighths of a mile wide, established by swinging the south jetty to the southward around its shore-end as a center until it occupies the line DZ, and leaving the north jetty located on the line CX, as before, it will be necessary to raise the submerged portions an average of about 14 inches higher than the crests shown on the longitudinal sections CX and DY, Plate II, in order to maintain in the seaward profile, 1½ miles from the jetty-heads, the same hydraulic radius deduced for the half-mile gap. Between the jetty-heads the hydraulic radius for the five-eighths-mile gap would be about 4.45 feet less than for the half-mile gap. Under both suppositions the sea-ends of the jetties rise to high-water level for a length of 1,500 feet on the north jetty, and 2,000 feet on the south jetty.

There seems to be little room for doubt that a channel of ample capacity having been once established through the bar, it will be permanently maintained by the jetties, and that the materials more or less constantly carried out by the current, especially during the prevalence of drift-

producing storms, and immediately subsequent thereto, will not be deposited under conditions favorable to the formation of an exterior bar.

The outer slope of the bar, directly to the seaward of the jetties, will perhaps assume and maintain a salient form in consequence of the materials being first brought to a temporary rest at that point; but unless the main body of the bar to the northward and southward of the jetties also moves bodily to the seaward in a marked degree, in violation of all known or suspected laws, the movement of drift will go on substantially as at present, finding only a transient resting-place in front of the new channel, or upon any other portion of the bar.

Having assumed the width between the jetties and the points on the bar at which their sea-ends should rest, it is not claimed that the corresponding height capable of maintaining through the bar to deep water on the outside a channel of a specified capacity can be determined with precision by computations based on the use of any known formulæ. But it seems quite clear, with the large surplus of available water not needed between the jetties, that we can by first building them low throughout their entire length, and then raising them gradually to the required height, utilize the flow, and accomplish the desired results, not only with certainty, but with the greatest attainable degree of economy.

It will be expedient, from other considerations, to proceed gradually in raising the works to the requisite height. It will be seen from Plate II, containing a record of the borings, that at the point D, nearly in the axis of the new channel, and a little outside a right line joining the sea-ends of the jetties, a bed of "soft mud and sand" 7 feet in thickness is encountered at a depth of 5 feet below the bottom, and 17 feet below mean low-water. It overlies a bed of sand 4½ feet thick. At E, about 460 yards to seaward of the point D, and also in the line of the new channel, a layer or thin bed of sand, shells, and soft mud, only 1 foot thick, is found 1 foot below the bottom, and 13 feet below low-water. At a depth of 6½ feet a 1-foot bed or lumps of stiff clay exists resting on 10½ feet of fine sand. At A, more than 1¼ miles inside the jetty-head, and a little to the northward of the probable line of deepest water, a bed of tenacious clay is found 4 feet below the bottom and 18 feet below low-water, while outside the gap at F, about a half a mile in a southerly direction from D, no clay or mud is found until a depth of 28 feet below low-water is reached, and there it is only a foot thick, and rests upon 3 feet of "shells and sand."

These borings show that the material which may be found capable of resisting erosion and removal by the currents does not occur in continuous and regular strata, but apparently in detached sheets, lumps, and beds, varying greatly in thickness and in depth below the bottom, and below the water-level.

It is presumed that none of the materials which it would be necessary to remove in establishing a deep-water channel through the bar can be eroded and carried off by the currents except those designated in the table of borings as "shells," "sand," "soft mud," or a mixture of two or all of them. Whenever stiff clay is to be removed some method of dredging or harrowing will have to be adopted, and it may be necessary to resort to harrowing in aid of the natural scour, to get rid of some of the beds of mud and softer clays. The sand and shells will be carried out by the current.

When the jetties, supposed for the present to be built of riprap resting on a mattress of fascines, have reached their full length, or rather their assumed length, from the shores to the points X and Y, respectively, with heights throughout the submerged portions not much greater than

may be deemed necessary to secure the foundations from injury by undermining, the lower sections should then be gradually built up until a sufficient flow is established between them to scour off the surface-layer of sand, shells, and soft mud, and lay bare the beds of stiff mud and clay between the heads of the jetties, and as far beyond them as possible, consistent with the safety of the works themselves. The greatest effect will naturally be produced along the center line, and the volume of flow should not be made large enough to cause any considerable scour along the faces of the jetties.

Dredging, if it becomes necessary at all, should begin along the line of greatest scour as soon as the removal of the clay by that method becomes practicable, and as greater depths are secured in this manner the jetties should be raised to higher levels.

The borings indicate that sooner or later, during this stage of progress, it will become necessary to determine in what manner the needed depths to seaward upon the outer slope of the bar can best be established. It may be done either by enlarging the area of the water-way between and directly in front of the jetties, so as to lengthen the outward reach of the scouring power, or by extending the jetties themselves farther out on the bar with only moderate depths between them, thus carrying farther to seaward the point at which divergence and consequent loss of power begin. In the degree to which the first method, if adopted, is carried into execution, will the jetties approach the heights shown in sections CX and DY, Plate II? and they could not theoretically attain and exceed those heights until the channel in the gap has a mean half-tide area of 113,160 square feet, and a hydraulic radius of 42.22 feet. This implies, as already stated, a deep central channel with maximum depths, which would perhaps be impossible of attainment at moderate cost by any known process of dredging or raking.

The boring at D in the line of the new channel indicates that very little dredging or raking would have to be done to reach a depth of 31 feet below mean low-water, there being only 6 inches of stiff clay to penetrate in that distance, and that is found at a depth of 28½ feet. At E, farther out on the same channel line, only 12 inches of stiff clay is encountered in a depth of 30 feet. Whether this material occurs nearer the surface, or in thicker beds at other points where its removal would be necessary to give the requisite water-way, cannot, of course, be known from the examinations that have been made. Very numerous borings taken near each other would be necessary before even a very general estimate could be made of the quantity of materials of different kinds that would require removal by other agencies than the natural scour, in order to attain any given area of water-way.

It is probable that the thin deposits of clay encountered in boring are only detached lumps or small masses that will be no obstacle to the prosecution of the work, but will settle down the lower levels as the sand is scoured away from around and beneath them. The existence of such lumps on the bottom of the inner harbor has been reported by divers.

For the purpose of this estimate, maximum mid-channel depths in the gap of only 31 feet at mean low-water will be adopted, because that depth appears to involve only a small outlay for dredging, and possibly none at all.

By fixing the crests of the submerged portions of the jetties at the requisite heights, we have the means of maintaining in this water-way average depths not much less than the maximum depths, thus producing a wide channel with moderate depths instead of a narrow channel very deep along the central line and shoal toward the sides. Under these

conditions the hydraulic radius in the gap can be made comparatively large. It will be taken at 24 feet mean half-tide.

It appears from calculations based as before on an assumed divergence of 60 degrees in the ebb-flow exterior to the jetty-heads, that a normal flow through the half-mile gap, with a hydraulic radius of 24 feet, cannot maintain a channel exceeding 21 feet in depth at mean low-water for a greater distance than about 5,500 feet beyond the heads of the jetties where the divergence begins. This would make the jetties 2,400 feet longer than the jetties CX and DY, already discussed, although their submerged crests would be considerably lower. The north jetty, if kept generally parallel to the bottom, would not exceed 1 foot in average height, its office being mainly to prevent the enlargement of the Beach Channel water-way by scour. The south jetty would have its submerged crest at 10.78 feet below mean low-water, if kept level throughout. Under these circumstances, with a 24-foot hydraulic radius in the gap, and corresponding hydraulic radii in the seaward profiles, on the supposed total divergence of 60 degrees, the original slope will be restored. The mean average ebb velocity through the gap will be 0.93 foot per second.

By raising their submerged portions above the calculated heights last mentioned greater ebb-flow and velocities would be established in the gap, with correspondingly increased power and outward reach, and, therefore, increased depths through the outer slope of the bar into the deep water beyond. But this would give no greater depths in the gap, under the supposition that beds of clay exist there at and below the depth of 31 feet, the only condition which appears to impose the necessity of low jetties at all.

If the submerged crests be placed at the varying heights shown in sections CX′ and DY′, Plate II, the total areas over the jetties and through the gap will be somewhat diminished, and as the areas are all fixed, while the volume to be discharged remains the same, there will ensue in the gap a banking up of the waters and consequently an increase of slope and of velocity. The computations show that the natural slope of 0.000002498, or about $\frac{5}{3}\frac{5}{2}$ inch to the mile, will be increased to 0.000004963, equal to about $\frac{5}{16}$ inch per mile; and the previous mean average velocity of 0.93 foot per second will be augmented to 1.09 feet per second. At what distance beyond the jetty-heads the original slope will be resumed cannot be ascertained by any process of computation, and consequently the distances beyond the points X and Y to which the jetties should be carried in order to maintain a channel of the required depth through the outer slope of the bar is largely conjectural. It is certain that they will not have to be extended as far as in the case of the low jetties last discussed. The calculations show, however, that, with the assumed divergence of 60 degrees, the heads of the jetties, or the point where divergence begins, need not be located more than 1,390 feet to seaward of the points X and Y, Plate I. This places their heads at X′ and Y′, respectively.

The practical solution of this question would of course be given by a gradual and cautious building up of the jetties, with frequent observations of their effects, care being taken that they are not raised so high as to prevent the complete filling of the tidal basin by each flood.

Numerous borings would of course be made before definitely fixing the width between the jetties, as it is possible that beds of material incapable of removal by natural scour may exist at such moderate depth that the half-mile gap should give place to a considerably wider one, a question which will doubtless turn mainly on the quantity of material that may require to be excavated by dredging.

No change of this character and for this purpose, if judicicusly made,

would materially alter the estimated quantities of materials needed for the construction of the works.

The volume of water, a little more than thirty-six hundred and fifty-five millions of cubic feet (3,655,374,296), which is supposed, in the foregoing discussion, to pass out through the gorge of the harbor on each ordinary ebb-tide, is believed to be less than the actual outflow of one tide.

Computations in all respects similar to those given above have been made on the supposition that the volume of outflow during each or ordinary tide is 4,834,000,000 of cubic feet, which is believed to be somewhat in excess of the actual outflow.

The computed hydraulic radius in the gap between the jetties is the same in both cases, which was to be expected, for the reason that we have only the calculated slopes and mean velocities to deal with, and that these vary with the volume of flow through the same section. The actual slope and velocity may be assumed to lie somewhere between those deduced in the two cases, and therefore to correspond to the deduced hydraulic radius. These theoretical results are of practical value only when they point to bottom velocities possessing a scouring power of sufficient intensity to maintain the new channel. In the case under discussion they theoretically satisfy that condition. Greater velocities could of course be established between the jetties by raising them higher, and in the seaward profile by extending them further out upon the bar.

It is quite likely that there would be an advantage in locating the sea-ends of the jetties about one-fourth of a mile to the southward of the points indicated on Plate I. This would place the center of the half-mile gap at the point Y, where the sea-end of the south jetty is placed in the drawing, and would turn the axis of the new channel more away from the prevailing storms which come from the northeast. The jetties in these positions are shown in Plate I, by heavy broken lines. It is not intended in this project to fix definitely either the length or the height of the jetties, or their precise location or distance apart, but to submit a general plan of improvement by means of submerged jetties that shall have their crests, throughout those portions which cross the thread of the current, at a height corresponding to the least width of the gap between them, the objects sought by this method being to lessen the first cost of the jetties, and to obviate the necessity of their subsequent extension.

The foregoing discussion will be revised if necessary in a supplementary report, as soon as the actual velocities and slopes have been ascertained by observation.

CONSTRUCTION AND ESTIMATES.

The jetties to which the following estimates apply are those last discussed, located on the lines CX′ and DY′, Plate I. The varying heights to which they rise above the bottom are shown by heavy parallel hatching in longitudinal sections CXX′ and DYY′, Plate II.

Their sea-ends for a length of 3,000 feet on the north jetty and 3,500 feet on the south jetty have their crests at the level of half flood of spring-tides, or three feet above mean low-water.

The total length of the north jetty is 8,840 feet, and that of the south jetty 13,040 feet. They are to consist of a superstructure of riprap stones with rather low side slopes resting on a mattress of fascines 2 feet thick.

The slope on the exterior faces of the jetties will be 1 upon 2 through-

out their entire length. On the interior faces it will be 1 upon 1½ except on the sea-ends, where, for a distance of about half a mile, it will be 1 upon 2.

For the north jetty the minimum width on top is 15 feet. This is in the lowest portion where it crosses Beach Channel. From that point outward the width increases to 24 feet, which is adopted for that portion which rises above mean low-water level.

The south jetty has a minimum width of crest of 12 feet where it crosses the main channel, at depths varying from 10 to 15 feet below mean low-water. Thence outward the width increases to 24 feet for the highest part, as in the case of the north jetty.

It cannot perhaps be safely assumed that beds of clay which may be encountered near the surface are sufficiently firm to resist the weight of the works without considerable subsidence. Where such beds, however, are overlaid by a thick stratum of sand, or a mixture of sand and shells, no great disturbance may be expected.

Where the jetties are constantly submerged they will not exert a pressure upon the mattress foundation exceeding 91 pounds per square foot for every foot in height, to which must be added, where the work rises above low-water level, about 59 pounds more for each foot in height during the time they are out of water. This takes no account of any lateral distribution of weight, which must in a greater or less degree take place in riprap constructions.

There being only two points where the actual pressure upon the bottom will approach near to one ton per square foot, while it will generally fall below one-half ton, it is believed that no settlement or disturbance of a very serious character will be likely to take place. At the two points referred to, in the main channel, both weight and cost could be reduced by replacing a portion of the hearting of the jetty with mattresses similar to those used for the foundation, as shown in Fig. 2, Plate II, care being taken to keep the wood well inside the riprap, so that after the voids in the latter have become filled with sand it would be safe from the ravages of worms. During the progress of work the voids could be filled at moderate cost by pumping from the bottom near by.

The quantities given in the following estimate assume the jetties above the foundation mattresses to be built of riprap only. The probable saving in cost that might be made by using a hearting of mattresses wherever admissible in both jetties is given in a separate item.

In calculating the quantities, the mattress foundation is supposed to rest one foot below the surface of the bottom, thus adding one foot to the depths shown in the cross-sections and diminishing the allowance to be made for subsidence and compression.

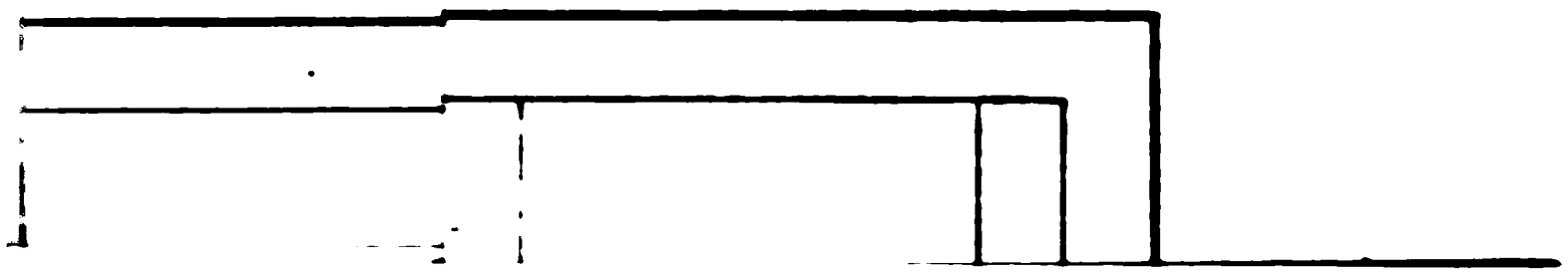
At present prices a liberal estimate for the riprap work is $5.50 per cubic yard, and for mattresses $1.50 per square yard, 2 feet thick.

NORTH JETTY.

58,000 square yards of mattress foundation, at $1.50	$87,000	
71,000 cubic yards of riprap, at $5.50	390,500	
		$477,500

SOUTH JETTY.

87,400 square yards of mattress foundation, at $1.50	131,000	
138,600 cubic yards riprap, at $5.60	762,300	
		893,300
Total cost for both jetties, all riprap above foundation		1,370,800



Add for false work, piles, &c	$100,000
Add 26 per cent. for subsidence, compression, and contingencies on in-shore or submerged portions of jetties	230,280
Add 37 per cent. for subsidence, compression, and contingencies on seaward ends of jetties	179,420
Excavating by dredging and raking, by contract, necessary in depths less than 31 feet below mean low-water	76,000
For eighteen months' work of United States dredging-steamer Henry Burden, rendered at various times in connection with other work (including current repairs and renewals of vessel and machinery)	26,000
Office expenses, superintendence, inspectors, &c., for four years	65,000
	2,047,500
Subtract for hearting of mattresses where admissible	247,500
Total estimated cost	1,800,000

In the execution of works of the character and magnitude of those contemplated in the foregoing project there are many advantages in having the funds supplied in liberal sums.

If the project be adopted the annual appropriation of about one-fourth the entire amount of the estimate for four successive years is very desirable. The completion of the work in three years would accomplish a considerable saving in the aggregate cost.

Respectfully submitted.

Q. A. GILLMORE,
Lieut. Col. of Engineers, Brevet Major-General, U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

PRELIMINARY REPORT OF BOARD OF ENGINEERS.

ARMY BUILDING,
New York, April 24, 1878.

GENERAL: The board of officers of the Corps of Engineers, constituted by Special Orders No. 28, Headquarters Corps of Engineers, Washington, D. C., March 19, 1878, with instructions to take into consideration and report upon a project for the permanent improvement of the channel of entrance into Charleston Harbor, South Carolina, submitted by General Gillmore, have the honor to submit this preliminary report.

The board have examined the project in question so far as this could be done without additional information as to the surface and bottom velocities upon the bar.

The board have also, in a general way, discussed the project for an improvement of the channel by ordinary jetties rising above low-water and more distant from each other than in the plan presented for investigation, and General Gillmore has made an approximate estimate for the same.

But it is not the intention of the board at present to define the jetties in any precise manner as to their distance apart, their extent measured from the shore, or the heights with respect to low-water to which these structures should be carried. All such points will be discussed in a future report based upon all the information which the locality can furnish pertinent to the subject. But the board is of opinion that the channel over the bar can be improved, to a probable depth at mean low-water of 21 feet, by the use of jetties submerged in whole or in part, and by

a mode of construction very gradual in its progress, which will admit of such modifications in the lengths and heights of the jetties as experience shall dictate. And, further, the board concurs with the views expressed by General Gillmore in his report that the project adopted should disturb to the least possible degree the present regimen of influx and efflux over the bar.

According to the extent of the project which may be adopted the cost will be from $1,800,000 to $3,000,000.

Respectfully submitted.

Z. B. TOWER,
Colonel of Engineers, Brevet Major-General.
H. G. WRIGHT,
Lieut. Col. of Engineers, Brevet Major-General.
JOHN NEWTON,
Lieut. Col. of Engineers, Brevet Major-General.
Q. A. GILLMORE,
Lieut. Col. of Engineers, Brevet Major-General.
Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

H 2.

IMPROVEMENT OF SAVANNAH RIVER AND HARBOR, GEORGIA.

The work that has been carried on during the past fiscal year, for the improvement of the navigation of the Savannah River, has consisted mainly in dredging at three points, viz: First, on the shoal northeast of Fort Pulaski; second, on the shoal southwest from Oyster Bed light, near Fort Pulaski; and, third, in the new channel at "The Wrecks."

At the close of the fiscal year my assistant, Capt. James C. Post, Corps of Engineers, aided by George Daubeney, assistant engineer, was engaged in gauging the stream at several points, with a view to securing some requisite data for an intelligent discussion of such questions of improvement as are likely to arise during the expenditure of the appropriation now available for this point.

Captain Post's report for the last fiscal year is transmitted herewith.

WORK CONTEMPLATED DURING THE PRESENT FISCAL YEAR.

I do not consider it expedient or proper to attempt to specify at this time, except in a very general way, all the work to which the sum of $70,000 appropriated by act approved June 18, 1878, should be devoted.

Heretofore the demands of commerce often seemed to require the expenditure of money with special reference to the speedy amelioration of existing evils, and with no great regard to the permanency of the improvement accomplished. Dredging has, therefore, been freely resorted to, even at points where it was presumed the work would have to be in part repeated. All the new channels, however, have been essentially permanent up to the present time, although they have perhaps reached the maximum depths which can be judiciously established by dredging alone. Low training-walls will have to be constructed at a few points for the purpose of narrowing the water-way, while at others the channel will require widening.

A project for this class of works will be prepared at the proper time.

The first work to be done during the present fiscal year is the construction of the submerged dam, composed of riprap resting on a mattress of fascines, or a brush and timber foundation, already approved for the Cross Tides.

When this has been carried up as high as may, in the first instance, be deemed desirable, and when the effects which the increased ebb-flow in the Front River produces or is likely to produce in the channel along the city front and upon the shoal known as Garden Bank, as well as in the new channel at "The Wrecks," have been observed and studied, the proper time will have arrived for preparing a project for future work.

The completion of the work of gauging the stream at several points, and the construction of the Cross Tides Dam, are the only operations that I am, as yet, prepared to recommend for the present fiscal year.

This work of improvement is located in the customs district of Savannah.

The important commercial interests to be benefited by the proposed improvements are indicated by the letter of Hon. John F. Wheaton, mayor of the city of Savannah, and the tables of commercial statistics extracted from the mayor's annual report for the year 1877, appended hereto.

The estimated cost of the contemplated improvements of the Savannah River, submitted August 28, 1873, not including the cost of the necessary bulkhead along the amended water-way, and jetties and bulkheads elsewhere, is $481,320.

The amounts and dates of the appropriations made since the adoption of the present project are as follows:

By act approved June 23, 1874	$50,000 00
By act approved March 3, 1875	70,000 00
By act approved August 14, 1876	62,000 00
By act approved June 18, 1878	70,000 00
Total	252,000 00

Of this amount there had been expended up to the close of the last fiscal year (including outstanding liabilities) $181,558.70.

Money statement.

July 1, 1877, amount available	$37,137 32	
Amount appropriated by act approved June 18, 1878	70,000 00	
		$107,137 32
July 1, 1878, amount expended during fiscal year	36,453 83	
July 1, 1878, outstanding liabilities	242 19	
		36,696 02
July 1, 1878, amount available		70,441 30
Amount (estimated) required for completion of existing project		229,320 00
Amount that can be profitably expended in fiscal year ending June 30, 1880		150,000 00

REPORT OF CAPTAIN JAMES C. POST, CORPS OF ENGINEERS.

SAVANNAH, GA., *July* 8, 1878.

COLONEL: I have to submit the following report upon the work for the improvement of the Savannah River for the fiscal year ending June 30, 1878:

The following are the places at which operations have been conducted, viz:

1st. New channel at "The Wrecks."

2d. The shoal southwest from the Oyster Bed light and northwest of Fort Pulaski.

3d. The channel northeast of Fort Pulaski.

4th. The Cross Tides.

At the completion of the contracts with the American Dredging Company and the City of Savannah, mentioned in the last annual report, the latter being completed in August and the former in September, the new channel at "The Wrecks" had been made 102 feet wide and 13 feet deep mean low-water. This channel by the scour of the ebb-tide has now widened materially for nearly half its length, from the western end, though somewhat irregularly, retaining at the same time the full dredged depth of 13 feet mean low-water. The lower half of the eastern portion, without a material increase of width, has shoaled in two places to 12 feet mean low-water. To determine the true cause of this shoaling at the present time is somewhat difficult, as it may be the result of two independent actions: First, the natural flow of the tides, and secondly, the grounding of two or three vessels against the sides of the channel where they remained through two or three tides. As the running aground of these vessels must have broken down the sides, and thus interrupted the free passage of water through the channel, I am inclined to attribute this diminution of depth to this latter cause rather than to the former. The success of this new channel has, during the past season, been of great assistance to commerce, as vessels drawing the full draught of water with which they can cross the "obstructions" or lower flats at high-water, have been enabled to pass to and from the city without delay, on either ebb or flood tide, provided they reached the lower flats at high-water. By adopting this course, several vessels on spring-tides have left the city drawing 18 feet 4 inches and proceeded to Venus Point on one tide, whereas, before the channel was opened, 16 feet 6 inches was the maximum draught that could pass out, and even with this, it was more than probable that two tides would be consumed, on account of it being necessary to pass through "The Wrecks" Channel at high-water. The real value of the new channel, in its present state, to commerce can therefore be placed at 1 foot 10 inches of draught, or nearly 2 feet, besides making the navigation of this portion of the river much easier by being direct and straight.

The dredging steamer Henry Burden continued working in the channel northeast of Fort Pulaski until July 27, when it was decided to transfer her to Charleston, S. C. From the 1st to 27th of July 9,656 cubic yards were removed. During the month of April 7,815 cubic yards were also removed from this channel by the steamer Burden.

The shoal opposite the Oyster Bed light continuing to increase, it became such an obstacle to navigation that in March it was necessary to commence its removal. Accordingly, on March 25, the steamer Henry Burden commenced work at this point. This, however, was discontinued after working about two weeks and removing only 2,948 cubic yards, as it was found that the presence of the wreck caused the steamer to work at such a disadvantage that it was decided to employ a dredge with the ordinary equipment for the removal of this wreck and shoal. A contract was, in consequence, made with the American Dredging Company for the removal of 8,000 cubic yards of material at 40 cents per yard; such portions of the wreck to be removed as came into the lines specified for the dredging. At the conclusion of this contract the channel at this point was increased 120 feet in width, and deepened to 14 feet mean low-water.

Ten piles, which acted as an obstacle to the navigation of the Cross-Tides, were also removed by the above-mentioned company.

In order to complete the data already obtained for the thorough discussion of the improvement of this river, a series of observations were commenced about June 1 to ascertain the amount of water flowing through the different river channels, and also to ascertain the amount of fall in each of them. To explain the method determined upon more fully, it may first be well to divide the river from the Cross-Tides to Tybee Roads into three sections, numbered 1, 2, and 3, successively, viz:

1st section.—All that portion of the river included between the Cross-Tides and Fort Jackson.

2d section.—That portion from the head of Elba Island to the head of Long Island.

3d section.—The portion including the shoal at the Oyster Bed light and the channel northeast of Fort Pulaski.

In each of these sections any work of improvement made in any portion has a direct bearing upon all the other portions.

To obtain the requisite data for the 1st section, it was determined to gauge the Cross-Tides, and also Front River between Kings and Marsh Islands, and to obtain the fall through the Cross-Tides and the different portions of Front River to Fort Jackson.

In the 2d section it is intended to gauge both the north and south channels near the junction at the head of Elba Island, and to make current-observations in each of the openings between the islands on the south side of the north channel, to ascertain what will be the effect of closing them. To determine the effect of any improvement of this portion of the river upon the ebb and flow in Saint Augustine Creek, it is also intended to make current-observations at its entrance into South Channel. The fall in the river through the section will also be obtained.

In the 3d section, the results of the improvement made during the past month upon the channel abreast of the Oyster Bed light will determine the best course to pursue in regard to it.

Thus far, the only data obtained is the high and low water slope, through the Cross-Tides and Front River, to the eastern end of Fig Island. Through the Cross-Tides, the mean of 10 observations gave the water practically level at high-water, while at low-water the same number of observations gave a fall of 0.19 of a foot, or 2⅛ inches, which is at the rate of 3⅛ inches per mile. From the Cross-Tides through Front River, the fall at high-water, the mean of 14 observations, is 0.3 of a foot, or 3½ inches, and at low-water 1 foot. The distance between the tide-gauge at the Cross-Tides and that at Fig Island wharf is nearly 6 miles; the fall, therefore, through Front River will average 0.6 of an inch at high-water and two inches at low-water per mile. The Cross-Tides has also been gauged, but sufficient time has not elapsed since its completion to enable the data to be worked out. These observations will be continued and completed as rapidly as possible.

Soundings taken during the past week in all the channels dredged during previous years indicate that they remain about the same as reported last year. This includes the channel between King's and Hutchinson's Islands, at Garden Bank, at the "obstructions" or head of Elba Island, and the upper and lower flats. The depth of water on the western end of Garden Bank has increased materially since last year. The old channel at "The Wrecks" has now shoaled to 8 feet mean low-water.

Very respectfully, your obedient servant,

JAS. C. POST,
Captain of Engineers.

Lieut. Col. Q. A. GILLMORE,
Corps of Engineers, U. S. A.

COMMERCIAL STATISTICS.

CITY OF SAVANNAH,
Mayor's Office, June 8, 1878.

GENERAL: I have the honor to acknowledge receipt of your letter of the 27th ultimo, and herewith submit a general statement of the information you request.

The section of country from which Savannah derives its business embraces Georgia, Florida, Alabama, Mississippi, Tennessee, and that portion of South Carolina bordering, or adjacent to the Savannah River. This country is made tributary to the business of the city, by the Central Railroad of Georgia, extending to Augusta 130 miles, to Atlanta 300 miles, to Columbus and Opelika 330 miles, to Eufaula 300 miles, with connections at all these points with roads running through South Carolina, Tennessee, Alabama, Mississippi, and to all points north, south, and west; by the Atlantic and Gulf Railroad to Bainbridge, on the Flint and Apalachicola Rivers, 260 miles, to Albany 220 miles, and to Live Oak, Fla., 160 miles, connecting at the latter point with Jacksonville, Pensacola, and Mobile Railroads, and all the other railroads in that State; by the Savannah, Altamaha, Satilla, and Saint Mary's Rivers, on all of which there are regular lines of steamers making semi-weekly trips; also by steamers with Florida, running along the coast of Georgia and Florida, to and up the Saint John's River. For the statistics of foreign and domestic exports for the year 1877, I refer you to the mayor's report for that year, pages 94 and 95, copy of which I mail you under a separate cover. It is proper to remark that the epidemic of yellow fever which prevailed here in the fall of 1876, materially decreased the business of the port for the year 1877, at a reasonable estimate diverting 100,000 bales of cotton to other ports, besides large quantities of other merchandise.

The exports for the year 1878 will be largely in excess of 1877, the receipts and exports of cotton amounting to this time to over 600,000 bales. It is estimated that the total exports for the cotton year 1877–'78 will exceed 650,000 bales, 200,000 barrels naval stores, 50,000,000 feet lumber and timber, 25,000 tierces of rice, and 30,000 bales of wool, and a very large increase of the fruit and vegetable trade, and in merchandise generally. These estimates are based on actual figures to this time. It is confidently expected that the receipts of cotton at this port for the cotton year 1878–'79 will reach 800,000 bales. This increase will result from the increased facilities for moving merchandise promptly and safely.

During the past year two steamers, in addition to those previously on that trade, have been placed on the line to New York, and two others are now building for the same line, that will be completed in September next; all of over 2,100 tons capacity and drawing 16½ feet of water loaded.

There has also been a decided improvement in the steamers trading to Baltimore, much larger and finer ships being now employed than have been in the past. It is also noticeable that the sailing-vessels that trade at this port, are generally of larger tonnage than heretofore, and during the past spring there have been several instances of ships going from our wharves to sea drawing 18 feet 3 inches of water. The tonnage statistics for the year 1877 show a larger amount of tonnage visiting this port

than for several years previously, and there is every reason to suppose that a much greater tonnage will be required the coming season.

* * * * * * *

Very respectfully, your obedient servant, JOHN F. WHEATON, *Mayor.*

Gen. Q. A. GILLMORE,
Lieutenant-Colonel of Engineers.

Imports, port of Savannah, 1877.

Articles.	Unit of quantity.	Quantity.	Value.
Salt	Pounds	13,733,271	$24,233 00
Coffee	do	2,245,263	397,320 00
Coal	Tons	1,479	3,060 00
Sugar	Pounds	89,556	4,612 00
Molasses	Gallons	95,781	22,044 00
Cotton-ties	Bundles	16,383	15,643 00
Chains	Pounds	29,852	1,247 00
Superphosphate	Tons	725	12,164 00
Brimstone	do	725	15,370 00
Sponge			10,972 00
Earthenware			1,167 00
Fruits of all kinds			8,769 00
Silver coin			27,945 00
Gold coin			820 00
All articles not above specified			19,571 00
Total			564,937 00
Total import duty collected			34,959 93

Foreign exports, port of Savannah, 1877.

Articles.	Quantity.	Value.
Cotton, upland, 288,533 bales	135,393,504	$15,669,574
Cotton, sea-island, 1,219 bales	425,374	124,797
Naval stores		83,790
Lumber, feet	17,675,000	245,368
Shingles, thousands	301	1,417
Timber, cubic feet	481,888	70,406
All other articles not specified above		48,729
Total value		16,244,081

MEMORANDA.—The exports of cotton (foreign) above, represent the transactions of the commercial year commencing September 1, 1876, and ending August 31, 1877.

Coastwise exports, port of Savannah, 1877.

	Quantity.
Cotton, upland, bales	217,472
Cotton, sea-island, bales	7,179
Hides (baled), bales	2,181
Hides (single), number	18,559
Domestic and yarn, bales	11,866
Rice, casks	16,812
Timber, sup. ft	2,500,000
Lumber, sup. ft	25,314,972
Rosin, barrels	102,274
Spirits turpentine, barrels	18,453
Wool, bales	1,143
Moss, bales	312
Old iron, tons	1,031
Paper stock, bales	733
Fruit, packages	23,284
Vegetables, packages	20,405
Melons, number	26,345
Clay, casks	282
Sponge, bales	376
Coffee, sacks	237
Sugar (hogsheads, 2,194; barrels, 3,590)	.....
Sirup (hogsheads, 115; barrels, 365)	.....
Merchandise, miscellaneous, packages	59,291

Tonnage for the port of Savannah for 1877.

	Tonnage.	Men.
American vessels entered	40, 948	951
American vessels cleared	44, 829	1, 066
Foreign vessels entered	168, 247	3, 950
Foreign vessels cleared	103, 342	2, 589
Total foreign	357, 366	8, 556
Coastwise arrivals	379, 826	10, 867
Coastwise clearances	439, 370	12, 081
	819, 196	22, 948
Total coastwise	819, 196	22, 948
Total foreign	357, 366	8, 556
Grand total	1, 176, 562	31, 504

Cotton statistics, port of Savannah, from July 1, 1865, to December 31, 1877.

		EXPORTS.									IMPORTS.		
		Foreign.							Coastwise.				
		Upland cotton.			Sea-island cotton.			All other.	Upland.	Sea island.			
From—	To—	Bales.	Pounds.	Value.	Bales.	Pounds.	Value.	Value.	Bales.	Bales.	From—	Value.	Duty.
July 1, 1865	June 30, 1866	60, 144	27, 666, 005	$11, 415, 919	3, 891	1, 206, 243	$1, 179, 581	$295, 153	159, 298	3, 648	Aug. 1 to Dec. 31, 1865	$121, 309	$76, 595
July 1, 1866	June 30, 1867	101, 737	48, 678, 828	14, 922, 058	8, 137	2, 522, 061	1, 375, 469	443, 984	140, 396	6, 700	Jan. 1 to Dec. 31, 1866	280, 976	165, 776
July 1, 1867	June 30, 1868	268, 671	123, 589, 580	23, 104, 262	6, 467	2, 004, 618	1, 070, 718	469, 120	234, 434	5, 195	Jan. 1 to Dec. 31, 1867	443, 329	215, 124
July 1, 1868	June 30, 1869	164, 674	75, 724, 254	19, 629, 712	3, 329	1, 031, 919	803, 907	616, 037	184, 690	3, 308	Jan. 1 to Dec. 31, 1868	490, 173	257, 265
July 1, 1869	June 30, 1870	260, 366	119, 685, 715	28, 352, 810	6, 488	2, 011, 244	905, 398	490, 880	197, 033	7, 696	Jan. 1 to Dec. 31, 1869	955, 469	496, 987
July 1, 1870	June 30, 1871	478, 941	220, 313, 007	32, 223, 301	2, 568	795, 402	281, 092	480, 375	248, 326	4, 424	Jan. 1 to Dec. 31, 1870	884, 870	410, 097
July 1, 1871	June 30, 1872	289, 030	144, 110, 476	27, 637, 634	1, 061	339, 283	192, 283	432, 198	151, 335	4, 300	Jan. 1 to Dec. 31, 1871	1, 019, 195	286, 283
July 1, 1872	June 30, 1873	373, 793	170, 020, 030	26, 814, 324	2, 395	767, 734	310, 716	466, 980	224, 048	5, 307	Jan. 1 to Dec. 31, 1872	780, 246	214, 703
July 1, 1873	Jan. 1, 1874	177, 509	83, 522, 982	12, 179, 873	970	329, 126	97, 287	163, 123	138, 181	989	Jan. 1 to Dec. 31, 1873	890, 644	128, 128
Jan. 1, 1874	Jan. 1, 1875	455, 910	214, 766, 835	31, 466, 288	3, 339	1, 114, 821	343, 077	417, 888	202, 712	3, 244	Jan. 1 to Dec. 31, 1874	788, 220	87, 590
Jan. 1, 1875	Jan. 1, 1876	408, 176	202, 659, 072	27, 347, 690	2, 661	904, 740	266, 000	333, 157	275, 001	4, 814	Jan. 1 to Dec. 31, 1875	511, 818	57, 936
Jan. 1, 1876	Jan. 1, 1877	325, 405	150, 662, 515	20, 500, 515	1, 461	496, 740	138, 785	337, 522	215, 106	4, 775	Jan. 1 to Dec. 31, 1876	511, 528	26, 087
Jan. 1, 1877	Jan. 1, 1878	384, 625	158, 267, 392	21, 154, 540	994	347, 900	89, 460	449, 710	217, 472	7, 179	Jan. 1 to Dec. 31, 1877	564, 937	34, 960
		3, 748, 984	3, 739, 666, 691	296, 748, 926	43, 761	13, 871, 831	7, 054, 813	5, 396, 127	2, 588, 032	61, 579	.....	8, 242, 714	2, 457, 531

DEPTH OF WATER SAVANNAH BAR AND ANCHORAGE.—Depth of water Savannah Bar, 26 feet mean high-water, 19 feet mean low-water; depth of water Tybee Roads anchorage, 38 feet mean high-water, 31 feet mean low-water.

FACILITIES FOR REPAIRS OF VESSELS—WILLINK'S MARINE RAILWAY.—260 feet length of cradle, with improved appliances accompanying.

SAVANNAH GRAVING DOCK—CAISSON-GATE.—Length of dock, 345 feet; breadth of base, 45 feet; breadth of top, 80 feet; floating capacity of dock, 16½ feet.

H 3.

IMPROVEMENT OF SAINT AUGUSTINE CREEK (THUNDERBOLT RIVER), GEORGIA.

This river forms part of the inside passage between the Savannah River and Wassaw Sound, and is used by the steamers plying between Savannah, Brunswick, Darien, Fernandina, and the towns on the Saint John's River, Florida.

The only improvement needed has already been recommended more than once, viz, the removal of a heavy timber dry-dock sunk there during the civil war. It now lies directly in the channel in 20 to 25 feet of water, and constitutes a very dangerous obstruction. A number of casualties of greater or less importance have already been caused by it. Its length is 225 feet, depth 25 feet, and breadth 65 feet, its thickness on the bottom being 3 feet, and on the sides 6 feet and upward. Its removal to a depth of 10 feet mean low-water will suffice. No appropriation has ever been made by Congress for the improvement of this stream.

Appropriation recommended for this purpose $5,000 00

H 4.

IMPROVEMENT OF THE HARBOR AT DARIEN, GEORGIA.

The act of Congress approved June 18, 1878, appropriates the sum of $8,000 for the improvement of the harbor at Darien, Ga. This appropriation, which is the first that has been made for this purpose, is not based upon any preliminary survey or upon any project prepared by me or under my direction.

The town of Darien is situated on Darien River, 11 or 12 miles from Doboy Sound, measured along the tortuous channel of the stream. The river enters the sound by two mouths, one of which, called Back River, between Commodore and Wolf Islands, was the subject of correspondence with the Chief of Engineers in the winter of 1874–'75, with reference to its improvement by the United States. A shoal, with only 9 to 10 feet of water upon it, existed in the channel-way and interfered with the business of shipping lumber and timber, which is carried on to a very considerable extent in that locality.

During the present fiscal year the sum appropriated will be expended in deepening the water on this shoal. It is presumed that the whole of it will be required for this purpose.

This improvement is in the customs-district of Brunswick, Ga.

No recent commercial statistics are at hand. The exportation of timber and lumber, as shown in the appended table, indicates the extent to which the general commerce of the country may be benefited by the proposed improvement.

Money statement.

Amount appropriated by act approved June 18, 1878	$8,000 00
July 1, 1878, amount available	8,000 00
Amount (estimated) required for completion of existing project	8,000 00

Statement of marine and export trade of Darien, Ga, showing shipments of timber and lumber in the years 1871 to 1874 inclusive.

Year.	Timber.	Lumber.
	Feet.	*Feet.*
1871	21, 141, 125	14, 123, 710
1872	30, 500, 655	17, 039, 717
1873	49, 885, 437	19, 896, 431
1874	59, 563, 341	18, 164, 809

H 5.

INSIDE PASSAGE BETWEEN THE SAINT JOHN'S RIVER AND FERNANDINA, FLORIDA.

No work was done upon this passage during the fiscal year just closed, there being no funds available for the purpose, and no money was provided for the present fiscal year.

I made a trip through this passage in a small light-draught steamer in February, 1878, and ascertained from the master and pilots that no material changes had taken place since the date of the last annual report. Nor is there likely to be any change so long as the channel is used by steamboats. At the most contracted point, through Gunnison's Cut, the channel at low-water is scarcely 30 feet wide and not more than 2½ feet deep. It is maintained at those dimensions by the passing of vessels through it.

Near the entrance into the Saint John's River there is another very narrow point.

The propriety of enlarging the passage at both these points admits of no doubt, so long as the channel of entrance into the Saint John's River over the bar at its mouth remains unimproved. The examination of that bar, which will soon be made, may result in a project for permanent works of improvement. Should this be the case, followed by an appropriation by Congress for beginning the works, the idea of improving the inside passage might very properly be abandoned. Otherwise it ought to be enlarged and maintained.

It is recommended that an appropriation of $10,000 be made, which will be applicable to the improvement of the inside passage between the Saint John's River and Fernandina, or to the bar at the mouth of Saint John's River, Florida, as the Secretary of War shall direct.

H 6.

IMPROVEMENT OF THE BAR AT THE MOUTH OF SAINT JOHN'S RIVER, FLORIDA.

No work was done during the last fiscal year, no funds being available for this improvement.

By act approved June 18, 1878, the sum of $10,000 was appropriated "for deepening the bar at the mouth of Saint John's River, Florida."

It is proposed to expend out of this sum whatever may be necessary in making an examination of the lower portion of the stream and the bar at its mouth, in order to obtain the requisite data for a project for works of permanent improvement. The stream will be gauged at several points,

and borings will be made upon the bar in order to ascertain the character of the materials of which it is composed, and their capacity for supporting heavy works. This examination will probably cost $2,500. A project for expending the balance of the $10,000 will be submitted at an early day.

Money statement.

Amount appropriated by act approved June 18, 1878	$10,000 00
July 1, 1878, amount available	10,000 00

REPORT OF LIEUTENANT H. G. WRIGHT, UNITED STATES ENGINEERS, MAY 24, 1853.*

WASHINGTON, D. C., *May* 24, 1853.

SIR: I have the honor to submit herewith a map of the survey of the entrance to the Saint John's River and Fort George Inlet, made by parties of the Coast Survey under an arrangement entered into with the superintendent, Prof. A. D. Bache. I have also to submit the following report in relation to the improvement of the bar contemplated by Congress in the appropriation made for that object.

The river Saint John's has its outlet in latitude 30° 20½′, runs in a westerly direction, or nearly perpendicular to the coast-line, to Jacksonville, an estimated distance by the windings of the channel of 25 miles, where it turns to the southward and runs nearly parallel to the coast for the remainder of its extent. Opposite to Jacksonville it is comparatively narrow and very deep; through the rest of its course from near its mouth to as high up as Palatka, and even somewhat above, an estimated distance of over 100 miles, it is broad and generally shallow with the exception of the channel. After passing the bar a depth of 12 to 15 feet may be carried to Jacksonville, and from 10 to 12 feet to Palatka. Unlike most rivers of the same magnitude it is seldom subject to heavy freshets in the rainy season, and its currents are principally the result of the tide. It is in fact rather a succession of lakes than a river, and may more properly be considered as an extensive lagoon, like Indian River. A little above Jacksonville its width is said to be about 5 miles.

Its importance to the development of the resources of the eastern section of the peninsula can hardly be overrated, penetrating as it does the heart of the country through several degrees of latitude, and furnishing a ready means of transporting its productions to a market. The country in its vicinity is being graduallly settled up, and its agricultural products are every year increasing. These all find their way to some point on the river from which they are shipped either to Savannah or Charleston. The lumber business is also increasing with surprising rapidity and is now become an important branch of industry, the lumber being shipped to our northern ports and the West Indies by brigs and schooners, of as great draught as can be carried over the bar. Nearly all the mills in East Florida are situated on this river. The contemplated ship-canal across the peninsula, the survey for which was provided for by Congress at the same time with the appropriation for the improvement of this river, must probably have its eastern terminus on the Saint John's, and will most likely be found impracticable for want of a suitable outlet, unless means can be devised for deepening its bar sufficiently to admit vessels of a large class. On the success of its improvement, too, rests the project for a railroad across the peninsula terminating at Jacksonville, a charter for which was granted at the last session of the State legislature.

The importance of the river to the prosperity of East Florida, and the advantages thus imperfectly set forth, which would be derived from an increased depth of water on its bar, so as to permit vessels of a large class to engage in its commerce, have for some time attracted the attention of persons interested in the advancement of their section of the State, and examinations were made with the view of devising some means of improving the navigation. One of these schemes, originating with Dr. Baldwin, has met with the most favor, and has been submitted by him to the department, and on his estimate the present appropriation is understood to have been made. As his plan embraced the inlet lying a little to the north of the mouth of the river, the survey on which the map now submitted was founded includes it within its limits.

I have given to the subject of this improvement the greater part of my attention during the past winter, and have studied it carefully, both as a matter of duty and from a feeling of interest in the success of any attempt to improve this the great river of Florida. The results of these investigations are contained on the map of the survey and in the following remarks.

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* Appendix S S, An. Rep. Chief of Engineers, 1853.—Ex. Doc. No. 1, H. R., 33d Cong., 1st sess.

The obstruction to navigation at the mouth of the Saint John's is the bar at its entrance, shown on the map, on which there is, at this time, only 7 feet of water at mean low tide. Bars are found at the entrances of all rivers, harbors, inlets, &c., with which I am acquainted, except those in the coral formations, and this one may, it is presumed, be fairly attributed to the same cause as similar bars at the entrances of rivers, &c., on our sandy coast, but not to the same as those at the mouths of rivers which, like the Mississippi, bring down large amounts of sediment from the interior of the country, which is deposited where the current of the river meets resistance enough from the great body of the exterior waters to deaden its velocity. The bar of the Saint John's is of hard sand, is disposed in a ridge which slopes off each way, and is, as may be expected, at the point where the current of the river is nearly deadened by the waters of the ocean. The water that flows in and out of the river is very free from sediment a short distance up the stream, and does not, I am sure, bring anything down in suspension that is deposited on the bar. What little is brought down in this way is deposited along the banks, in the channel, which has soft bottom in places, and perhaps outside the bar, where the soundings indicate soft bottom in spots.

What, then, is the source from which the bar is derived, and what the force that brings it into position? The answer seems plain. It is due to the ocean waters, and not to the waters of the river, and is placed in its present position by the combined action of the sea and the current of the river. Along the shore of this part of the State and, I believe, through the whole extent of our sandy coast the water for some distance from the shore-line is shallow, often leaving banks of pure, fine, siliceous sand bare, or nearly bare, at low-water. This shoal water extends out about the same distance from the shore at different points of the coast where the circumstances of exposure to the ocean and other disturbing causes are the same. Applying this to the coast, both above and below the entrance of the Saint John's, and we have a line of flats extending along the shore which, when acted upon by the current of the river, would undoubtedly be forced seaward to some extent, thus making a bend outward in the line. We therefore see where the river empties its waters into the ocean the outer edge of the shoal curves outward, being farther from the coast than either above or below. Over this bank or shoal the waters of the river pass, not in one direct line, but spreading out over its whole extent as soon as it loses the confinement of its banks. The whole volume is not spread out equally over the shoal, but a portion of it retains its direction, and continues on to the outer edge where the *bar proper* is found, and where the depth is greater than at any other point.

As the bar is a shifting one, it seems necessary to ascertain, if possible, all the facts connected with these changes; and, after many inquiries of pilots and others supposed to be best informed in the matter, I have come to the conclusion that the prime cause of every decided change is a heavy storm, which, by the heave of the sea and the temporary derangement of the current, destroys the existing relations between the usual forces, and establishes new relations among them, causing the waters to make their way out in a new direction, where the force opposing their egress is less than in the old one. It does not seem that this new direction is a permanent one, or rather the one it must necesarily keep till another storm occurs, but only a general course, from which it may change from day to day within slight limits. For instance, the present channel was found more than two years ago, and has been subject during the interval only to slight variations. At present it is working very slowly to the southward, a direction that seems more natural than its present one. Nor should it be understood that when a new channel is found it is completely formed—that any storm makes one where none was found before. The storm only causes such changes in the form of the shoals, depth of water, &c., as to make the commencement only, perhaps, of what will become the true channel, most subject to change; and the one referred to above as liable to shift as that outside of the inner buoy.

I have thus far spoken only of the shifting of the channel in direction, and not of any changes of depth on the bar. A variation of depth is liable to occur at any time, and does not, by any means, necessitate a change of direction or position of the bar, and is caused entirely by the direction and force of the wind. When the wind is off the land, and blows with violence for a considerable time, the rapidity and duration of the ebb current is much increased, and a deepening of the bar is the result. It is said, under such circumstances, to run out at least 18 hours in the 24. On the return of the wind to a direction on, or obliquely on shore, the bar soon fills up again to its usual depth. I shall have occasion to refer to this again when speaking of principles which must, in my opinion, govern in any improvement attempted.

The sand-hills and banks of the river near the mouth being of fine sand, are easily moved by the water and wind, and are prone to change in form and position when the wind is at all strong, a portion being carried into the river and thrown up in other places without affecting the depth on the bar. These sands seem confined to the river itself in their effects, changing the depth of water at various points not in the channel-way. For instance, the bank on the south side is rapidly progressing in past the light-house, having increased both in extent and height since I first arrived at the mouth of

the river, and, indeed, since the survey of this part was made; and this sand is derived, in part at least, from these banks and sand-hills. The shoals that extend out to the bar, as well as the bar itself, are also of this character of sand, easily moved by the current or heave of the sea, and but for the equilibrium established between the various forces tending to its motion, the shoals it forms would be sensibly changed from day to day. As it is, they are nearly stable, preserving generally the same shape and depth of water; and the same may be said of the bar itself.

The direction and force of the currents are distinctly shown on the map of the survey for the various points at which they were taken. In addition to these, which were obtained with great care by Captain Craven, with a float made for the purpose, he observed the direction and estimated the force of the current while making the soundings over the shoals on both sides of the outlet; the directions being determined by the way the boat tended when anchored for the purpose of taking the angles of position. The general directions of these were all seaward on the ebb-tide—the natural course they would take when spreading out, from being no longer confined by banks—and their velocity at no time exceeded half a knot, in his judgment. On the change of the tide the directions were reversed. Like all large estuaries, the directions of the current and tide do not change simultaneously, the ebb *current* here running from one to two hours after the flood-tide has commenced, and in strong westerly winds much longer. The same is true for the flood current and tide. It is not found, however, that there are any decided counter currents along the banks during this interval; so this rise must be accounted for by the swelling of the waters of the ocean meeting and raising the level of the water of the river, which, from its inertia of motion, continues to run for a time in spite of the force opposed to it.

Taking one of the tides, the ebb, for instance, and following the current within the the limits of the channel, it may be distinctly traced out over the bar proper; but on approaching the edge of the channel below the sand-point on the north bank, the current is there found to feather out over the shoals, and is dispersed into the waters of the ocean. Thus a considerable part of the water of the river is delivered not over the bar, but over the wide extent of this shoal, and its effect in deepening the bar consequently lost. The same may be said, to a less extent, of the currents over the breakers on the south side of the river.

Tidal observations were taken both on the river and on Fort George Inlet, which show a general concurrence in the times of high and low water in the two streams. This is not true of the current, which in the river continues to run, as has been before remarked, for from one to two hours, and in heavy winds still longer, after the tide has changed, while in the inlet the changes of tide and current are nearly simultaneous. The current and tidal observations also show that while the current in the river-channel continues to run after the tide has changed, that through the swashes changes nearly at the same time with the tide, and of course at the same time with that in the inlet. Taking the last of ebb, for instance, the current of the river runs out, spreading itself over the shoals till low-tide; but on the commencement of the flood, the ebb-current is mostly confined to the channel and out over the bar, while over the shoals and through the swashes, what current there is is in toward the river—that is, a flood current. The velocity of the current over the shoals and through the swashes is small in comparison with that in the main channel of the river. No current has been detected running from the bar to the inlet, or the reverse; and Captain Craven's observations discover no other current off shore than that produced by the wind. Along the outer edge of the shoal, the flood sets to the southward, and the ebb to the northward, the velocity not exceeding half a knot in moderate weather, but much influenced by the wind. There can be no question, I think, that in all the currents over the shoals, through the swashes or rudimental channels, and those exterior to the shoals, the direction and force of the wind exercise much influence over the direction and velocity of the currents—that what is true at one time and in one kind of weather may be found untrue at another—though I believe the above results are in conformity to the general law, and any departure from them will be found to be exceptions.

Having stated all the facts collected which seem important to the consideration of the subject, I will now give what seems to me the principles which must govern in any attempted improvement of the bar. It is seen that, under the same circumstances, the depth of water on the bar remains about the same; that when undisturbed by extraneous influences, no change takes place; but when this condition of equilibrium is disturbed, the depth of water at the principal outlet, and often its position, are changed; that westerly winds, which increase both the duration and velocity of the ebb-current, always tend to increase the depth at the bar, while winds on shore soon bring it again to its former condition. Merely deepening the bar, then, will be of no avail; it must soon fill up again, unless some means can be devised to prevent it. To gain this greater depth and retain it, a greater volume of water must be made to pass over the bar, requiring a greater space for its discharge, or what will be equivalent to increase of volume or greater velocity, or both combined. Of this there can be no two opinions. The effect of an increased volume would doubtless be to increase both width

and depth of the outlet; but would it increase its depth in proportion to the width? It seems to me not, if the width of the outlet over the bank is not restricted; for is it not a well-established fact that on these bars, after a certain depth is obtained, an increased velocity or volume increases width rather than depth; that sand is much easier moved near the surface by currents than at greater depths?

While I feel satisfied as to the principles that must govern in any attempted improvement, I am not so confident as to the means by which these principles should be carried out. Indeed, I am free to confess that I see no plan which I would be willing to submit as promising any certainty of success. In an undertaking of this kind the judgment of more than one person is desirable, as promising more reliable results from their united experience and skill, and in commanding the confidence of the public in the correctness of their decision. I would therefore suggest to the department the propriety of sending a commission to examine the river and submit a project before any action is taken.

As the instructions of the department, however, require me to submit a plan, it may be expected that one, however unsatisfactory, will be offered. It seems to me that the only project that can be at all reliable, is to confine to the channel the waters of the river that pass over the north shoal, by a breakwater running nearly parallel to the channel, and extending from the shore to as near the present bar as it can be carried, thus securing a much greater volume of water, and consequently a greater depth over the bar. That this would improve the bar, so long as the channel retains its present direction and position, there can be, I think, no question. What the result would be if the channel were to shift to the southward, cannot be so easily foretold. The influences, too, might and probably would be only temporary, from the sand gradually working out behind and beyond the extremity of the breakwater, and finally producing a bar farther seaward; though it does not seem that this danger is so great here as in the case of rivers whose bars are produced from deposits brought down in suspension by their currents.

While giving this as what appears to me the most apparent as well as the only project promising success, I am far from saying the plan is a practicable one. The sea breaks heavily over this bank a large portion of the time. The bank itself is of fine sand, easily moved by the water; and it would seem almost impossible to overcome all such obstacles as the heave of the sea and the excavating power of the currents, and construct anything upon it which would resist the violence of the storms at least at such cost as would be considered admissible. I may overestimate the difficulties of such an undertaking, but I think not. They will of course increase with the extent of the work from the shore, being greatest at the outer extremity.

Near the shore, say to the first shoal, the work would be comparatively easy of construction; and, indeed, the desired effect might be obtained by sinking a line of wrecks, against which the sand would be likely to accumulate sufficiently to form a barrier to resist the storms. It is not possible to foresee what action the water would produce on the sandy bottom along and particularly at the end of such a breakwater as is proposed; it might accumulate the sand or it might cut it away, leaving a deep channel. Nor is it possible to say how much effect should be expected from a short breakwater in deepening the bar, though some benefit to it must result, if the foregoing reasoning be correct.

I have not given any details of construction for such a work as is proposed, or any estimates of cost, as I have not had time to make one since the survey was finished. Nor would such details and estimates be of any service if, as I hope may be the case, the department should determine to refer the subject to a commission.

The only other project that has been at all studied is the one proposed by Dr. Baldwin, and which I return herewith, with the request that it be considered when the subject is examined. Dr. Baldwin has taken great interest in the question of the improvement of the bar; has examined the locality personally, and has come to the conclusions set forth in his report. His project is certainly a very ingenious one, the means required for its accomplishment very small, and his confidence in its success most sanguine. I am sorry I cannot agree with him, but my own convictions constrain me to differ entirely in opinion as to the promised success of his plan, which ought and I hope will be attentively considered by the department and board when the subject is investigated. I believe he intends to draw up another report, which shall embrace other facts, and place his theory in a shape more satisfactory to himself than in his original paper, and which he will forward to the department as soon as prepared.

A breakwater on the north shoal only is spoken of in the foregoing report, though one on the shoal on the south is required to carry out the project fully; but as the first is by far the most necessary, in my opinion, and should be the first tried, the other is not recommended at this time.

It was at first supposed that the protection of the light-house and the improvement of the river might both be effected by the same means, and authority was given to combine the two appropriations toward attaining the common object. As my report

to the Light-House Board proposes a project of operations entirely distinct from that recommended for the improvement of the river, the two appropriations ought to be hereafter separated.

Respectfully submitted.

H. G. WRIGHT,
Lieutenant of Engineers.

General J. G. TOTTEN,
Chief Engineer, Washington, D. C.

NOTES TO THE FOREGOING REPORT.

I have been struck by the fact that the mouths of the only rivers and inlets I have seen on this coast seem to be gradually working the southward—a coincidence that may be entirely accidental, or it may be the result of a general law. I have seen this in the case of Mosquito Inlet, from the sketch of Captain Rogers's survey; afterwards at Saint Augustine; then at Saint John's and Fort George Inlet; and I understand the same is true for Saint Mary's, or rather the entrance to Cumberland Sound.

The north bank of the Saint John's is marshy for several miles up, except the mere sand-bank just at the mouth, while the south is bordered by a range of sand-hills as far up as the mill. Along this southern shore, between high and low water, the marsh mud is found, in which the roots and stubs of the grass are still quite perfect; and this mud is also found underlying the sand-hills wherever wells have been dug, showing its connection with the marsh in rear. These sand-hills themselves are unquestionably gradually traveling to the southward, as is shown not only by this mud, but by the palmetto trees which are still growing out of the tops of the hills, but whose trunks are entirely buried up. Many of these trees are just being uncovered by the washing away of the face of the hills, their trunks being now exposed down to the roots, showing that they grew on ground but little above the high-water mark—that is, in rear of the sand-hills as they then existed.

As the great storms that affect the coast are mostly from the northeast, may not this gradual movement of the mouths of these rivers and the sand-hills on their banks be fairly attributed to their agency? It would seem to be a cause sufficiently powerful to produce such an effect, and is, moreover, the only apparent one. Storms from a direction off the land are often severe, but their influence in producing changes of this kind are small in comparison with the northeasters, which have a wide sweep over the ocean, and whose power is not diminished by the obstacles that are constantly opposed to the wind off the land. These last winds only serve to retard the effects that would be caused by the storms from the ocean, not to annul them.

If this supposition be true, may not the material of the bar of the river be derived from the sand along shore, which is thus driven to the southward by these storms into the current of the river, and deposited, in part, on the bar and shoals, and which constantly tend to move the bar further out? If so, will not a breakwater on the north shoal serve to arrest these sands and secure permanency to any improvement in depth produced by the contraction of the outlet?

I am inclined to think the shifting of the bar of this river to be less in amount than is generally asserted. If we look at the map, we see over the north shoal, near the entrance, two very distinct swashes, through which there is but about 2 feet less water than over the bar. Any storm from the southward, and perhaps any direction on shore, might act upon the present bar enough to incline the current through either of these, and produce in it a greater depth than through the present outlet. This current, when once established, would retain its direction till changed by another storm, or till gradually filled up as the old one opened. The same may be said of the south side, where there is full as much water as on the north side, though no swash channels. When an old channel becomes very bad—that is, should the pilots seek for better water and a new channel is proclaimed, they observe these changes only so far as they apply to their own business, taking little if any notice of others, however interesting or necessary to persons investigating the subject with a view to devising projects of improvement.

Once the channel ran out to the southward in a position not easy to define, but probably along, or perhaps over, the edge of the southern bank, but did not continue there long. It grew gradually worse, according to the testimony of Mr. Palna, an intelligent citizen of the vicinity, at that time engaged in the live-oak business, when a channel was found nearly or quite in the position of the present one. The current being divided between the two, neither possessed sufficient depth for the vessels he had engaged in freighting his timber, and he had it in contemplation to try to get an appropriation for sinking some old wrecks in the southern one to stop it up. Fortunately the straight one soon improved, and the other filled up itself.

Should any attempt to improve the bar be successful it would be necessary to make some improvement in the river between the mouth and Jacksonville in order that it may be available. Just below what is called Davis's Point, about 10 miles above the bar, the channel becomes very narrow, and as shallow as 12 feet, furnishing a depth at high-water of say 14 to 15 feet; a greater depth than this could be commanded to Jacksonville only by improvements at this point. Above Jacksonville the channel becomes shallow again, giving no greater available depth than 12 feet to Picolata, and 10 feet to Pilatka; so say the pilots. Rise of tide above Jacksonville, according to the same authorities, does not exceed 1 foot.

H. G. W.

APPENDIX I.

ANNUAL REPORT OF CAPTAIN A. N. DAMRELL, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1878.

UNITED STATES ENGINEER OFFICE,
Mobile, Ala., July 19, 1878.

GENERAL: I have the honor to transmit herewith annual reports, with financial statements, for the year 1877–'78, for the river and harbor improvements under my charge.

Very respectfully, your obedient servant,

A. N. DAMRELL,
Captain of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

I 1.

IMPROVEMENT OF HARBOR AT MOBILE, ALABAMA.

The opening of a 13-foot channel from Mobile River to the 13-foot curve in Mobile Bay was completed, as stated in my last year's report, in the month of September, 1876, and operations during this fiscal year were confined to the care and preservation of the public property appertaining to this work, and the removal of some sunken logs, which not only endangered navigation, but also showed a tendency to cause the channel through Choctaw Pass to fill.

The present condition of the channel remains unchanged, no complaints having been made by the pilots; 96 vessels of all descriptions drawing over 9 feet (52 of which drawing from 12 to 14 feet) have passed through this channel to and from the wharves of the city during the year.

In my last annual report I directed attention to the great advantages and benefit the commerce of this section of the country would derive from a deep-water channel from the lower anchorage in the bay to the wharves of the city of Mobile, and Congress, by act approved June 18, 1878, has appropriated the sum of $10,000 to be applied to making tests, surveys, and borings to determine whether the ship-channel now leading from the lower anchorage in Mobile Bay can be deepened so as to admit vessels drawing 22 feet, or any less draught above 13 feet, to the wharves at the city of Mobile.

It is proposed to commence these surveys and investigations as soon as the preparations for the necessary outfit for this work are completed.

Mobile harbor is in the collection district of Mobile, Ala., and Mobile is the port of entry.

The following statistics have been furnished me by the collector for this fiscal year:

American vessels entered from foreign countries for fiscal year ending June 30, 1878	64
American vessels cleared for foreign countries for fiscal year ending June 30, 1878	81
Foreign vessels entered from foreign countries for fiscal year ending June 30, 1878	75
Foreign vessels cleared for foreign countries for fiscal year ending June 30, 1878	78
Total amount of tonnage	165,845
Coastwise arrivals for fiscal year ending June 30, 1878	105
Coastwise clearances	55
Total amount of tonnage	34,427
Total imports for fiscal year ending June 30, 1878	$1,114,442 00
Total exports for fiscal year ending June 30, 1878	$9,126,634 00
Total amount revenue collected for fiscal year ending June 30, 1878	$51,714 23

Money statement.

July 1, 1877, amount available	$4,015 57	
Amount appropriated by act approved June 18, 1878	10,000 00	
		$14,015 57
July 1, 1878, amount expended during fiscal year		2,146 31
July 1, 1878, amount available		11,869 26

I 2.

IMPROVEMENT OF HARBOR AT PENSACOLA, FLORIDA.

By act of Congress approved June 18, 1878, an appropriation was made for the improvement of the harbor, including survey and estimate of removal of wrecks at Pensacola, Fla. The work proposed to be done under this appropriation is:

1. The removal of the wrecks near the entrance to this harbor by contract, each wreck to be bid for separately.

2. An examination or survey with necessary soundings, &c., to determine the most advantageous expenditure of any remaining balance of the appropriation, or for further recommendations for improvement of this harbor.

As soon as this project for the expenditure of this appropriation is approved, it is proposed to make all necessary preparations for the immediate prosecution of this work.

This harbor is situated in the collection-district of Pensacola, and Pensacola is the port of entry.

The following statement has been furnished me by the collector of customs for the fiscal year ending June 30, 1878:

Total number of vessels arrived, 579; tonnage, 296,363. Total number of vessels cleared, 596; tonnage, 306,190.

Import duties	$10,219 49
Tonnage dues	48,926 70
Hospital money collected	2,182 75
Exports to foreign countries	2,063,986 00
Exports coastwise	511,110 00
Total	2,636,424 94

Money statement.

Amount appropriated by act approved June 18, 1878	$20,000 00
July 1, 1878, amount available	20,000 00

I 3.

IMPROVEMENT OF HARBOR OF CEDAR KEYS, FLORIDA.

Under an appropriation of $10,000, made by act of Congress approved August 14, 1876, and made available by order of the honorable Secretary of War, dated March 3, 1877, a contract was entered into June 11, 1877, with James E. Slaughter, the lowest bidder, at 59½ cents per cubic yard for dredging inside the bar, and 92 cents per cubic yard for dredging on the outer bar. To ascertain the location where this appropriation could be most advantageously expended, a competent assistant was employed to examine into the practicability of making a cut across the middle ground between Way Key and Depot Key, and its advantages, who, after a thorough examination of the condition of the channel and the most pressing wants of the commerce of this place, reported favorably, and located it about a quarter of a mile south of the railroad wharf, thereby making nearly a straight channel from Grassy Key to the city, avoiding the tortuous channel north of said key.

This project having been approved by the Chief of Engineers by letter dated October 29, and the channel properly staked out by the assistant in charge, dredging operations were not commenced until November, the contractor being unable, on account of continued stormy weather during the summer months, to bring his dredge and scow to the work; and being aware that he could not complete his contract within the time specified, application for an extension of time from December 1, 1877, to February 15, 1878, was made. This extension of time having been granted by letter of the Chief of Engineers, dated December 8, 1877, dredging operations were carried on until February 13, when, the appropriation being exhausted, work was suspended.

The following is a statement of the number of cubic yards excavated during each month:

	Cubic yards.
November, 1877	1,326
December, 1877	3,025
January, 1878	6,686
February, 1878	3,184
Total	14,221

With this amount of excavation, a channel with an average width of 80 feet and a depth of 11½ feet at mean low tide through the Middle Ground has been attained, and up to the close of the year this channel has remained unchanged and is used by all vessels going to and from Way Keys.

By act of Congress June 18, 1878, an appropriation of $20,000 has been made for this improvement for the fiscal year ending June 30, 1879, and the work proposed to be done under this appropriation is:

1. Widening channel through Middle Ground from 80 feet to 200 feet, with the same depth.
2. Widening channel through Outer Bar from 100 feet to 200 feet, with the same depth.
3. Deepening channel east and south of Grassy Key.

The harbor of Cedar Keys is situated in the collection district of Saint Mark's, and Cedar Keys is the port of entry.

The following statistics have been furnished me by the collector of the port for this fiscal year:

Number of vessels entered, 134, with a tonnage of 50,986 tons; number of vessels cleared, 125, with a tonnage of 44,913 tons.

Value of exports of domestic produce, $13,403; value of imports, $3,058.

Amount of revenue collected, $3,473.75. The original cost of this improvement is $133,500.

Whole amount appropriated, $52,500.

An appropriation of $50,000, asked for, could be advantageously expended during the fiscal year ending June 30, 1880.

Money statement.

July 1, 1877, amount available	$9,983 65	
Amount appropriated by act approved June 18, 1878	20,000 00	
		$29,983 65
July 1, 1878, amount expended during fiscal year		9,983 65
July 1, 1878, amount available		20,000 00
Amount (estimated) required for completion of existing project		81,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880		50,000 00

I 4.

IMPROVEMENT OF CHOCTAWHATCHEE RIVER, ALABAMA AND FLORIDA.

Operations on this improvement, consisting in the removal of snags, cutting of overhanging trees, and deepening of shoals, were continued at the beginning of this fiscal year under an available balance of an appropriation made by act of Congress approved August 14, 1876. This work was carried on with a snag-boat, flat, and chartered steamer, as in the previous year, until the latter part of August, 1877, when, for want of funds, the force employed had to be discharged. Over 630 snags and 1,200 overhanging trees were removed, and the shoal at Miller's field deepened by removal of drift and gravel.

During the balance of the year operations were confined to the proper care of the property appertaining to this work.

No appropriation having been made for this improvement, no work is contemplated during next fiscal year.

Original estimated cost of the improvement, $34,332; amount appropriated, $15,000.

An appropriation of $19,000, asked for, could be advantageously expended during the fiscal year ending June 30, 1880.

The Choctawhatchee River is situated in the collection district of Pensacola, and Pensacola is the port of entry.

Money statement.

July 1, 1877, amount available	$2,786 38
July 1, 1878, amount expended during fiscal year	2,577 81
July 1, 1878, amount available	208 57
Amount (estimated) required for completion of existing project	19,332 00
Amount that can be profitably expended in fiscal year ending June 30, 1880	19,000 00

I 5.

IMPROVEMENT OF APALACHICOLA RIVER, FLORIDA.

This improvement was carried on under an unexpended balance of former appropriation.

In prosecution of the project of further improving of Moccasin Slough, on this river, the steam snag-boat Clara Dunning was moved from the Chat-

tahoochee River to that point in January, 1878, and work was continued until the middle of April. During this time a dam 130 feet long was constructed on the west side of upper end of Moccasin Slough; the point of land on the east side and a small island above the junction were cut away to straighten the channel and force a larger volume of water through the slough. Four hundred and eighty-six cubic yards of earth were excavated, over 270 logs and snags pulled out of the channel, and many overhanging trees cut and removed. Fifteen piles were also driven at the mouth of the river to afford protection to vessels during stormy weather.

By act of Congress approved June 18, 1878, an appropriation of $8,000 was made for the improvement of this river, and the following project submitted for its expenditure during fiscal year ending June 30, 1879:

1. To improve Apalachicola Cut-off and make the same navigable to White's Bluff, by the removal of snags, sunken logs, and shoals.
2. To widening and straightening channel of Moccasin Slough.
3. To removal of all sunken logs and trees which may interfere with or endanger navigation on this river.

This river is situated in the collection-district of Apalachicola, and Apalachicola is the port of entry.

The following statistics have been furnished me by the collector of this port:

Amount of revenue collected at the port of Apalachicola, Fla., during fiscal year ending June 30, 1878, from customs, $271.05.

Number of vessels entered during above period, 24; tonnage, 3,135.30. Number of vessels cleared during above period, 23; tonnage, 2,727.73. Number of vessels belonging to this district, 26; tonnage, 1,204.60.

Estimated amount of merchandise carried by vessels within the district of Apalachicola ———.

Original estimated cost of work	$30,000 00
Amount appropriated previously	20,000 00
Amount appropriated for fiscal year ending June 30, 1879	8,000 00

An appropriation of $20,000, asked for, could be advantageously expended during the fiscal year, June 30, 1880.

Money statement.

July 1, 1877, amount available	$4,776 91	
Amount appropriated by act approved June 18, 1878	8,000 00	
		$12,776 91
July 1, 1878, amount expended during fiscal year		4,074 33
Amount available		8,702 58
Amount (estimated) required for completion of existing project		52,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		20,000 00

I 6.

IMPROVEMENT OF CHATTAHOOCHEE AND FLINT RIVERS, GEORGIA.

CHATTAHOOCHEE RIVER.

At the close of last year the steam snag-boat was undergoing repairs, which were completed during the month of July, and work on the improvement of Wolfax Bar resumed To complete this work, it was found necessary to extend the shore protection on the Georgia side about 200 feet, lengthen the jetty on the Alabama side by brush-work about 570 feet, and to still further contract the channel, construct two short wing-dams 90 by 40 feet long. During the month of October these works

were completed, and there are now, at low-water, not less than 4 feet of water over this bar.

The bars at Abercrombie, Shell Creek, Chimneys Bluff, and Snake Shoals were greatly improved by the removal of snags, sunken logs, and overhanging trees, and the construction of about 200 feet of jetties, before work had to be suspended on account of high-water. The snag-boat and working-party transferred to the Apalachicola River.

The blasting party in the mean time were engaged in removing rocks from Uchee, Slick Bluff, and Hardridge's Shoals; over 600 cubic yards of rock were taken from the channel on those bars, besides a large number of snags and sunken logs. We have now a channel 60 feet wide by 4 feet at low-water over these shoals, which were very dangerous to navigation. On November 7, 1877, the boat engaged in blasting on the Chattahoochee was towed to Bainbridge on the Flint River, where the work was carried on during the remainder of the year.

By act of Congress approved June 18, 1878, an appropriation of $18,000 was made for the improvement of the Chattahoochee River, and the following project has been submitted for the expenditure of same during the fiscal year ending June 30, 1879:

It is contemplated during next year to continue the work on the improvement of the most dangerous shoals on the Chattahoochee River, such as Hardridge's Shoals and King's Rock, and then resume operations on the Flint.

FLINT RIVER.

Work on the improvement of this river was commenced in the early part of November, 1877, when the blasting boat and party were transferred from the Chattahoochee to the Flint River. The principal obstructions to navigation on this river are rock shoals, and the work during the year has been confined to the blasting of rocks and removal of snags. Beginning at the wharf at Bainbridge and working down to Lambert's Island, 763 cubic yards of rock and 168 sunken logs were removed, and for that distance a channel 4 feet deep and 60 feet wide at low-water has been obtained.

By act of Congress approved June 18, 1878, an appropriation of $10,000 was made for the improvement of the Flint River, and the following project has been submitted for the expenditure of same during the fiscal year ending June 30, 1879:

1. To continue the improvement on this river from Lambert's Island to its mouth, by blasting and removal of rocks, sunken logs, and overhanging trees.

2. To extending this improvement to river between Bainbridge and Albany, as far as the appropriation will permit.

Chattahoochee and Flint Rivers are in the collection districts of Mobile, Savannah, Brunswick, and Saint Mary's. The nearest port of entry is Apalachicola, Fla.

The following is the only information that could be obtained in regard to the statistics of the traffic carried on these rivers:

Number of articles. .	Value.	Freight.
32,850 bales of cotton	$1,971,000 00	$32,850 00
5,317 boxes of oranges	47,853 00	1,592 10
3,115 barrels of sirup	62,300 00	2,800 00
43,000 barrels of flour	387,000 00	12,900 00
31,304 sacks of corn	46,956 00	6,260 80
600,000 pounds of bacon	48,000 00	18,000 00
43,200 sacks of meal	64,800 00	8,640 00
51,000 packages assorted freight	2,963,000 00	16,940 00
Total	5,590,909 00	99,982 90

RECAPITULATION.

Values	$5,590,909 00
Freight	99,982 90
Passage	28,000 00
Total value	5,718,891 90
Original estimated cost of improvement	330,000 00
Total amount appropriated for both rivers	98,000 00
Appropriation asked for fiscal year ending June 30, 1880	50,000 00

Money statement.

July 1, 1877, amount available	$25,565 09	
Amount appropriated by act approved June 18, 1878	28,000 00	
		$53,565 09
July 1, 1878, amount expended during fiscal year		21,647 57
July 1, 1878, amount available		31,917 52
Amount (estimated) required for completion of existing project		232,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880		50,000 00

I 7.

IMPROVEMENT OF BLACK WARRIOR AND TOMBIGBEE RIVERS, ALABAMA.

The amount of funds available at the beginning of this fiscal year for the improvement of these rivers was not sufficient to justify the employment of a large working force, and in order to expend the same most advantageously, taking into consideration the boating interests on the rivers, it was deemed best to fit out one snag-boat and commence the removal of snags, sunken logs, and overhanging trees at the mouth of the Black Warrior River, and continue this work upstream as far as the amount available would permit. This was accordingly done, and although the season was short and the work repeatedly interrupted by rains and freshets, snags and overhanging trees were removed from the mouth of the river to Log Shoals, where, on November 7, 1877, operations had to be suspended.

The work done during the season amounts to the removal of 804 large logs and the cutting of 73 overhanging trees. From the mouth of the river to Eastport, a distance of 62 miles, there is now a low-water channel of 2½ feet minimum depth, which enable the light-draught boats running on this river to reach that place at all seasons.

The following are the statistics in regard to the trade on these rivers which I have been able to obtain:

Number of bales of cotton carried during the year	110,090
Value of bales of cotton carried during the year	$5,702,662
Estimated value of merchandise	$4,623,680

By act of Congress approved June 18, 1878, an appropriation of $28,000 was made for these rivers, and the following projects have been submitted for the expenditure of same for the fiscal year ending June 30, 1879:

1. To continue the improvement of the Warrior River from Eastport to Tuscaloosa.

2. To the removal of all snags, sunken logs, and overhanging trees,

and the improvement of the worst bars on the Tombigbee River from Demopolis to its mouth.

Original estimated cost of work	$172,603 00
Whole amount appropriated	68,000 00
Appropriation asked for fiscal year ending June 30, 1880	100,000 00

Money statement.

July 1, 1877, amount available	$5,463 04	
Amount appropriated by act approved June 18, 1878	40,000 00	
		$45,463 04
July 1, 1878, amount expended during the fiscal year		4,318 24
July 1, 1878, amount available		41,144 80
Amount (estimated) required for completion of existing project		104,603 00
Amount that can be profitably expended in fiscal year ending June 30, 1880		100,000 00

I 8.

IMPROVEMENT OF TOMBIGBEE RIVER ABOVE COLUMBUS, MISSISSIPPI.

The survey of this portion of the Tombigbee River was made during the fiscal year ending June 30, 1873, under the charge of Maj. Walter McFarland, Corps of Engineers, and for estimates and recommendations I would respectfully refer to his report contained in Annual Report Chief of Engineers, 1873, page 548.

The amount of $10,000 was appropriated by act of Congress approved March 3, 1873, for the improvement of the Tombigbee River, of which sum only $4,667.05 was expended above Columbus; the balance was used for the lower part of the river. No appropriations have been made since until by act of Congress approved June 18, 1878, $12,000 were appropriated for this improvement and the work put under my charge.

The following project has been submitted:

To the removal of snags, sunken logs, and overhanging trees, and the improvement of the worst bars on this river above Columbus, as far as the appropriation will allow.

The Tombigbee is in the collection district of Mobile, and Mobile is the port of entry.

Original estimated cost of the improvement	$35,000 00
Amount appropriated	16,667 05
Appropriation asked for and which can be profitably expended during fiscal year ending June 30, 1880	18,000 00

I 9.

IMPROVEMENT OF ALABAMA RIVER, ALABAMA.

The examination and survey of this river was made during the fiscal year ending June 30, 1876, and for estimates and recommendation for this improvement I would respectfully refer to my annual report of that year. (Report of Chief of Engineers, 1876, Part 1, page 498.)

By act of Congress approved June 18, 1878, an appropriation of $25,000 was made for the improvement of the Alabama River, and the following

project has been submitted for the expenditure of same during the fiscal year ending June 30, 1879:

1. To closing cut-off about 12 miles above the mouth of the river by the construction of substantial dams and necessary jetties, &c.

2. To removal of all snags, sunken logs, and overhanging trees from the mouth of the river to Wetumpka, Ala.

The Alabama River is in the collection district of Mobile, and Mobile is the port of entry.

The following are the statistics in regard to the trade of this river which I have been able to obtain:

Number of bales of cotton carried during the year	52,216
Value of bales of cotton carried during the year	$2,704,788 80
Estimated value of merchandise	2,350,000 00
Original estimated cost of the improvement	229,741 00
Total amount appropriated	25,000 00
Appropriation asked for fiscal year ending June 30, 1880	100,000 00

Money statement.

Amount appropriated by act approved June 18, 1878	$25,000 00
July 1, 1878, amount available	25,000 00
Amount (estimated) required for completion of existing project	229,741 00
Amount that can be profitably expended in fiscal year ending June 30, 1880	100,000 00

APPENDIX J.

ANNUAL REPORT OF CAPTAIN C. W. HOWELL, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1878.

UNITED STATES ENGINEER OFFICE,
New Orleans, La., July 24, 1878.

GENERAL: I have the honor to forward herewith the annual reports, for the fiscal year ending June 30, 1878, of the various works of river and harbor improvements under my charge.

Very respectfully, your obedient servant,

C. W. HOWELL,
Captain of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

J 1.

IMPROVEMENT OF THE MOUTH OF THE MISSISSIPPI RIVER AT SOUTHWEST PASS.

The work of dredging at Southwest Pass was continued until August 22, 1877.

The act approved August 14, 1876, appropriating money for the work, provided:

> That this appropriation shall not be available whenever and so long as there shall be an open channel of 18 feet of water, at mean tide, to and from the sea, through the South Pass of the Mississippi River to the port of New Orleans.

The depth of channel through South Pass provided for in the above-cited act having been reported by the inspecting officer of that work, instructions were received from the Chief of Engineers to suspend operations at Southwest Pass, which was done August 22, 1877, and the dredge-boats employed upon the work laid up at New Orleans.

A daily record of operations is given in the appended tabular statement, of which the following is a synopsis:

Table of dredging and its results.

Months.	Number of hours dredging on bar.	River (falling, −; rising, +; at stand, 0).	Number of days the channel had a depth at mean low tide as indicated below.			Tides ranging above mean low tide.	Number of vessels using channel.	Greatest draught of same.	Number of vessels detained.
			Feet, 17.	Inches, 16½.	Feet, 16.				
						Feet.		*Ft. In.*	
July	158.30	−, +, 0, +, −, +, −, +	.....	1	30	1⅜ to 3	37	20 5	6
August (to 22d)	64	+	20	2	.....	1⅜ to 2⅜	18	19 6	1
Total	222.30		20	3	30	.....	55	.....	7

Months.	Number of hours detention of vessels on bar, arranged according to draught of vessels detained.							
	20 ft. 5 in.	19 ft. 10 in.	19 ft. 6 in.	19 feet.	18 ft. 6 in.	15 feet.	13 ft. 6 in.	
July	*162	23	23	23	20	10	.....	Number of hours detention not known.
August	.....	.....	.....	.....	.....	.....	.....	
Total	162	23	23	23	20	10	.....	

*Steamer Chilian grounded June 24.

In response to advertisement inviting proposals for dredging at Sabine Pass, Texas, for which Congress had made provision, bids for the work had been received, and were being considered at the time work was suspended at Southwest Pass.

As the lowest responsible bid received would not have excavated a channel at Sabine Pass of the depth contemplated by the act appropriating, it was recommended that one of the idle dredge-boats be utilized for the purpose, which, it was thought, would be able to excavate a deeper channel at less cost than would have been obtained by acceptance of any of the bids.

This recommendation was approved by the Chief of Engineers. The *Essayons* was selected for the service, and sent to Sabine Pass November 22, 1877. The *Essayons* became disabled, and the *McAlester* was sent to relieve her. The latter vessel left this port January 1, 1878, and sailed from South Pass January 2, but never reached her destination.

Since, pieces of her wreck picked up in the Gulf leave no doubt that she was lost, probably in the severe storm of January 3, with all on board.

Immediately upon notification that the *McAlester* had not arrived at Sabine Pass, boats were dispatched from New Orleans and Galveston in search of her. These vessels cruised in every direction in the Gulf it was thought possible for the *McAlester* or her wreck to have drifted, with the hope of at least saving some of her crew. However, the search resulted in nothing beyond picking up a sky-light and hatch (supposed to have belonged to the *McAlester*) by the revenue-cutter McLane. Several weeks after her disappearance portions of houses recognized as belonging to the *McAlester* were picked up in the Gulf, which would seem to suggest that she probably foundered, and that the portions of wreck found were afterward detached from the hull at the bottom of the Gulf by action of the waves.

The end dock, coal-barge, and storehouse belonging to the work being of no further service that would justify the expense required to care for them, were sold at auction by direction of the Chief of Engineers.

Under the same authority the launch Survey was transferred to the work for improving harbor at Galveston, Tex., and the *Essayons* and other property transferred to the work for improving Sabine Pass, Texas.

The following statistics regarding the commerce of the port of New Orleans for the year ending June 30, 1878, have been kindly furnished by the collector of the port:

Entrances.			Clearances.		
Class.	No.	Tonnage.	Class.	No.	Tonnage.
Steam	428	616, 823	Steam	440	625, 974
Sail	778	430, 510	Sail	831	439, 031
Total number of vessels entered	1, 206	1, 047, 333	Total number of vessels cleared	1, 271	1, 065, 005

Total value of imports	$11, 140, 170 00
Total value of exports, domestic	85, 410, 884 00
Total value of exports, foreign	219, 475 00
	85, 630, 359 00
Total amount of revenue collected on imports	1, 601, 646 32

The work is located in the collection district of New Orleans and near the light-house at Southwest Pass. It is not susceptible of permanent completion.

Whole amount appropriated	$1,339,424 38
Whole amount expended	1,339,424 38

Money statement.

July 1, 1877, amount available	$10,760 98
August 6, 1877, amount allotted from appropriation for repairs, preservation, extension, and completion of river and harbor works	12,200 00
July 1, 1878, amount expended during fiscal year	22,960 98

Tabular statement accompanying report of Capt. C. W. Howell, on improving mouth of Mississippi River during the fiscal year ending June 30, 1878.

Date.	Stage of river at New Orleans, 12 m., below high-water of 1874. Gauge foot of Canal street.	Wind at Southwest Pass. 6 a. m. Direction.	Force.	12 m. Direction.	Force.	Hours worked by dredge-boat.	Depth of channel at mean low tide.	Height of high tide above mean low tide.	Total depth of channel at high tide.	Least width at mean low tide.	Number of vessels passed in.	Number of vessels passed out.	Casualties at Southwest Pass. Number of vessels aground.	Greatest draught.	Time of delay.	Remarks.
1877.	*Feet.*					*h. m.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*				*Ft. in.*	*h. m.*	
July 1	4.9	S. W.	1	S. W.	1	.....	16	1⅝	17⅝	80	1	.....	.....	.....	.....	
2	4.6	E.	1	E.	2	.....	16	2	18	60	.....	.....	.....	.....	.....	
3	4.7	E.	2	E.	3	6 00	16	2	18	60	.....	1	.....	.....	.....	
4	4.7	E.	3	E.	3	.....	16	2	18	60	.....	2	1	15	10*	*About. Bark New England grounded west of channel,
5	4.9	E.	2	E.	1	.....	16	2⅛	18⅛	40	.....	.....	.....	.....	.....	
6	4.6	S. W.	2	W.	3	.....	16	2¼	18¼	60	1	.....	.....	.....	.....	
7	4.7	W.	3	W.	3	5 30	16	2⅜	18⅜	75	.....	1	1	20 5	162	Steamer Chilian grounded June 24; got off.
8	4.5	E.	2	E.	3	3 30	16	3	19	60	.....	1	1	19	23	Steamer Jamaican grounded west of channel; got off July 9.
9	4.5	E.	1	E.	2	6 00	.....	.....	.....	.....	.....	1	.....	.....	.....	
10	4.7	E.	1	E.	1	.....	.....	.....	.....	.....	.....	1	1	18 6	20	Bark Fede Esperanza grounded west side of channel; got off July 11.
11	4.7	W. S. W.	1	N. W.	1	7 30	.....	.....	.....	.....	1	2	1	19 10	23	Bark Pendleton grounded; got off July 12.
12	4.4	W.	1	W.	1	.....	16	3	19	60	.....	3	.....	.....	.....	
13	4.5	W.	1	W.	1	7 40	.....	.....	.....	.....	.....	1	.....	.....	.....	
14	4.4	W.	1	S.	1	7 30	16	2½	18½	90	.....	1	.....	.....	.....	
15	4.5	S. E.	3	E.	4	6 30	16	2⅝	18⅝	80	2	.....	.....	.....	.....	
16	4.4	E.	3	E.	3	7 00	16	2¾	18¾	90	2	.....	.....	.....	.....	
17	4.5	E.	1	E.	2	10 15	16	2⅞	18⅞	90	.....	.....	.....	.....	.....	
18	4.6	S.	2	S.	2	10 30	16	2⅞	18⅞	100	.....	1	.....	.....	.....	
19	4.7	S. W.	2	W.	5	.....	.....	.....	.....	.....	2	.....	.....	.....	.....	
20	4.8	W.	2	W.	1	10 50	16	2⅞	18⅞	100	1	.....	.....	.....	.....	
21	4.9	N. W.	3	N. W.	3	10 30	16	2⅞	18⅞	80	1	.....	.....	.....	.....	
22	4.10	N. W.	3	N. E.	3	9 15	16	2¾	18¾	90	1	3	1	19 6	23	Ship Baden grounded; got off July 23.
23	4.10	N. W.	3	W.	1	9 00	16	3	19	100	.....	3	.....	.....	.....	
24	4.10	N. E.	3	E.	3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
25	4.10	E.	2	W.	5	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	
26	4.11	E.	2	E.	1	9 00	16	2¾	18¾	100	.....	.....	.....	.....	.....	
27	5.0	E.	1	E.	1	7 00	16	2⅝	18⅝	100	.....	.....	.....	.....	.....	
28	5.2	E.	1	E.	1	6 00	16	2½	18½	80	.....	.....	.....	.....	.....	
29	5.3	W.	1	W.	1	6 00	16	2	18	100	1	1	.....	.....	.....	
30	5.4	W.	2	W.	1	6 00	16	2	18	100	.....	1	.....	.....	.....	
31	5.4	W.	3	W.	1	7 00	16⅛	1⅞	18⅛	80	.....	.....	.....	.....	.....	

Tabular statement accompanying report of Capt. C. W. Howell, on improving the mouth of Mississippi River, &c.—Continued.

Date.	State of river at New Orleans, 12 m., below high-water of 1874. Gauge foot of Canal street.	Wind at Southwest Pass.				Hours worked by dredge-boat.	Depth of channel at mean low tide.	Height of high tide above mean low tide.	Total depth of channel at high tide.	Least width at mean low tide.	Number of vessels passed in.	Number of vessels passed out.	Causalties at Southwest Pass.			Remarks.
		6 a. m.		12 m.									Number of vessels aground.	Greatest draught.	Time of delay.	
		Direction.	Force.	Direction.	Force.											
1877.	*Feet.*					*h. m.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*				*Ft. in.*	*h. m.*	
Aug. 1	5.9	.....	.....	.....	.....	10 00	16½	2	18½	70	.....	.....	.....	.....	.....	
2	7.1	.....	.....	.....	.....	8 00	17	2	19	50	1	.....	.....	.....	.....	
3	7.1	.....	.....	.....	.....	9 25	17	2¼	19¼	80	.....	.....	.....	.....	.....	
4	7.2	.....	.....	.....	.....	4 30	17	2¼	19¼	80	.....	.....	.....	.....	.....	
5	7.3	.....	.....	.....	.....	10 25	17	2¼	19¼	80	2	.....	.....	.....	.....	
6	8.4	.....	.....	.....	.....	8 00	17	2½	19½	100	1	1	.....	.....	.....	
7	8.4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	
8	8.8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	
9	9.3	.....	.....	.....	.....	3 00	16½	2¼	18¾	100	.....	.....	.....	.....	.....	
10	9.8	.....	.....	.....	.....	5 25	17	2¼	19¼	100	1	.....	.....	.....	.....	
11	10.3	.....	.....	.....	.....	.....	17	2	19	100	.....	1	.....	.....	.....	
12	10.7	.....	.....	.....	.....	4 00	17	1¾	18¾	90	.....	2	.....	.....	.....	
13	10.11	.....	.....	.....	.....	.....	17	1¾	18¾	90	.....	.....	.....	.....	.....	
14	11.05	.....	.....	.....	.....	1 15	17	1¾	18¾	70	.....	.....	.....	.....	.....	
15	11.8	.....	.....	.....	.....	.....	17	2	19	60	.....	.....	.....	.....	.....	
16	11.7	.....	.....	.....	.....	.....	17	2¼	19¼	100	.....	1	.....	.....	.....	
17	11.7	.....	.....	.....	.....	.....	17	2½	19½	80	.....	.....	1	13 6	.....	Ship Belgravia grounded west of channel; date of getting off not known.
18	11.7	.....	.....	.....	.....	.....	17	2¼	19¼	95	.....	3	.....	.....	.....	
19	11.8	.....	.....	.....	.....	.....	17	2¼	19¼	100	.....	1	.....	.....	.....	
20	11.9	.....	.....	.....	.....	.....	17	3	20	100	.....	.....	.....	.....	.....	
21	11.10	.....	.....	.....	.....	.....	17	2¾	19¾	100	.....	1	.....	.....	.....	
22	12.03	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	Operations at Southwest Pass suspended, and the Essayons ordered to New Orleans.
Total..	.....	.....	.....	.....	.....	222 30	.....	.....	.....	.....	19	36	7	.....	261	

J 2.

IPROVEMENT OF THE ENTRANCE TO GALVESTON HARBOR, TEXAS.

he following reports from my assistants, Capt. C. E. L. B. Davis, ps of Engineers, and Mr. H. C. Ripley, assistant engineer, are re- ctfully submitted as my annual report:

REPORT OF CAPTAIN CHARLES E. L. B. DAVIS, CORPS OF ENGINEERS.

* * * * * * *

ıe work was continued up to 30th of November, 1877, when operations were sus- led, owing to the appropriation having become exhausted.
l work was discontinued, except the necessary watching of public property, until 12th of June, 1878, on which date I arrived in Galveston, and, in obedience to in- tions from you, made arrangements for the immediate resumption of work, and, ıe receipt of telegraphic instructions from you on the 15th, immediately commenced ations.

REPAIR OF BREAKWATER AT FORT POINT.

ıe repairs to the breakwater were completed September 7, 1877, some 1,200 pal- o piles being used for the work, varying in length from 18 to 24 feet.
ıring the heavy gale of September, the 16th and 17th, this breakwater was badly aged, and was left in about the same condition as it was before the repairs were ıenced. Where new pile-work had been put down it stood, but all of the old ıg which had been patched up was carried away.
is hardly probable that had the whole breakwater been built anew it would have ıstood the storm, as the scour during the heavy September gales is so great that ile-work, unless heavily ballasted, can escape undermining.

BOLIVAR POINT GABIONNADE.

ıis work consisted first of a double row of pine piling, capped and braced, with t-piling on the sea-side. This was continued out 513 feet, where the gabionnade er was commenced in 6 feet of water. The piling showed indications of being rmined, so barrels and bags filled with sand and fascine mats loaded with concrete ks were used to protect the base from scour. These repairs were completed Sep- ber 15, 1877, and two days afterward, during the September gale, the entire struct- was swept away.
ıring the year 316 gabions were sunk in this gabionnade, making a total of 330 ons, or very nearly 4,000 running feet.
the water was quite shoal, averaging but little over 6 feet, the gabions were sunk ıout any mats being placed under them. They have all settled quite uniformly.
settlement during the September storm amounted to about 4 feet, leaving the top ıe gabionnade but little above the general surface of the bottom; therefore the ons of this line will hereafter be placed upon mats.

CONSTRUCTION GROUND AT BOLIVAR POINT.

	Gabions.
ıand July 30, 1877	681
ıe construction-ground at Bolivar the number of gabions constructed during e year was	38
Total	719
ions placed in Bolivar Point gabionnade	316
	403
ions washed off scow during September storm	4
On hand June 30, 1878	399

r the construction of fascines, mats, and concrete blocks, repairs to buildings and t, attention is respectfully invited to the accompanying report of Mr. William e, overseer.*

* * * * * * *

* Report not forwarded to Chief of Engineers.

I transmit herewith report of Mr. H. C. Ripley, assistant engineer, of the survey work done during the year ending June 30, 1878, together with the tide and wind record for the same period.*

As work was resumed so late in the month of June, it has not been possible to complete the survey of the outer bar.

* * * * * * *

Very respectfully, your obedient servant,

CHAS. E. L. B. DAVIS,
Captain of Engineers.

REPORT OF MR. H. C. RIPLEY, ASSISTANT ENGINEER.

The surveys have been principally hydrographic, and have been conducted with a view to the exact delineation of those changes which have occurred in the harbor either as the result of storms or through the direct influence of the gabionnades, or of both, and to the determination of the positions of gabions in the gabionnade.

Monthly reports have been submitted during the progress of the work, together with tracings of surveys made at the time, in which the changes occurring from month to month have been indicated in detail, so that it seems necessary in this report only to indicate those general changes which will serve to compare one year with another, and which will show the actual progress made during the year.

INNER BAR.

The changes in the channel across the inner bar have been progressive since the completion of the Fort Point gabionnade in June, 1877.

The following table shows the depths of water which could be carried across the bar at times of surveys:†

	Feet.
June, 1877	16
July, 1877	16½
August, 1877	16½
September, 1877	18½
October, 1877	19½
February, 1878 (reconnaissance)	20
June, 1878	20½

The depths after August were modified by a shoal inside of the bar proper which was not affected by the gabionnade.

From the inner end of the gabionnade across the bar the depths were as follows:

	Feet.
September, 1877	19½
October, 1877	20
June, 1878	22½

This shoaling seems to be the result of a cross-current from the old swash channel around the end and through the breaks in the pile breakwater. There is, nevertheless, a channel-width of 500 feet between the 18-foot curves, and a channel-width of 200 feet between the 20-foot curves.

From the inner end of the gabionnade to Bolivar Channel there is a 22½-foot channel, with a least width of 500 feet between the 20-foot curves.

OUTER BAR.

But one survey of the outer bar has been made during the year, that of September 20 and 21, 1877, immediately following the equinoctial storm. As shown by this survey, unimportant changes have occurred. The channel had shifted a little to the south, and another channel had opened about a mile south of the old one, with a least depth of 12½ feet, and the 18-foot curve in Bolivar Channel had been pushed out, diminishing the distance across the bar between the 18-foot curves 1,300 feet. There seems to be no tendency to re-establish the old ship-channel as far as is shown by this survey and a reconnaissance made on the 10th ultimo.

BOLIVAR GABIONNADE.

As the construction of Bolivar gabionnade progressed, the position of each gabion was carefully located and plotted so as to show its longitudinal and lateral inclination

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* Tide and wind record not forwarded to the Chief of Engineers.

† Soundings referred to plane of mean low-tide.—C. W. H.

and its distance from the outer surface of mean low-tide. The gabions usually settle from 1 to 1½ feet in a few days from the time of being put down, and are seldom level after settling, but incline more or less to one side or the other, generally to the north.

This inclination is usually small, but in some cases amounts to from 30° to 40°. At the time of the September storm, 2,833 feet of gabionnade had been constructed, and throughout this entire length the gabions settled during the storm about 4 feet, leaving the top of the gabionnade but little above the general surface of the bottom; a trench having been excavated close along the south side of the gabionnade which allowed the settling to take place, there having been no mats underneath to prevent it. By a recent reconnaissance of the gabionnade, it seems that this trench still exists.

Aside from the trench, which reached a depth of 12½ feet close to the gabionnade, sloping up to the normal depth at a distance of about 400 feet, no scour has occurred, but on the contrary a slight accumulation has taken place for a distance of 100 feet on either side of the line.

The injury done to the gabions during the storm was very slight, consisting mainly of the breaking of a few tops. The fact that the tops of the first five gabions from shore were all carried away seems significant, suggesting some modification of the form of the gabion which will better secure it from injury when placed in shoal water where it may be exposed to the whole force of the waves.

The following table shows the progress in construction made each month since the gabionnade was commenced:

Month of—	Length.	Gabions.	Total length.	Remarks.
1877.	*Feet.*	*Number.*	*Feet.*	
June	170	14	170	
July	614	51	784	
August	1,813	165	2,597	
September	236	Undetermined.	2,833	
October	406	....do	3,239	
November	730	....do	3,969	Approximate.

The total length of the gabionnade is given as approximate, for it was not practicable when the location was made to locate the extreme outer end, but a point three gabion lengths from the outer end was located and the length of the three gabions, estimated at 36 feet, was added to give the position of the outer end.

In my last annual report the length of gabionnade constructed was given at 172 feet, whereas in the above table it is given at 170 feet. The error was made last year by assuming the length of each gabion to be 12 feet and adding to the length thus determined the aggregate of the spaces between them measured before the gabions had settled.

When the location was actually made and a discrepancy discovered, a careful measurement of a number of gabions, selected at random, gave an average length on top of 11.73 feet.

All gabions put down to August 31, inclusive, have been carefully located, and tracings of plots forwarded. Those put down in September were so much settled by the storm that it was not practicable to determine their inclinations accurately, and the attempt, therefore, was abandoned. The location of those put down in October and November was not completed when work was suspended, and hence no tracing has been forwarded.

It was very much desired to make another survey of the outer bar and vicinity of Bolivar gabionnade before the 30th of June, but on account of the late resumption of work and the delay in getting the steam-launch in running order it was impossible to do so.

TIDE AND WIND.

The records of the tide and wind have been kept by means of self-recording gauge and anemometer, and the curves are plotted on the accompanying chart.

The following table shows the mean low-tide for each nodical period as compared with the plane of established mean low; + indicating above, and — indicating below that plane:

Number of period.	Mean low, in feet.	Number of period.	Mean low in feet.
1	+ .17	8	— .07
2	+ .12	9	— .47
3	— .02	10	— .25
4	+ .08	11	+ .26
5	+ .82	12	— .09
6	+ .08	13	+ .35
7	— .34	13½	— .12

The plane of mean low-tide for the year is $\frac{4}{100}$ feet above the plane of mean low-tide established at the Brick wharf, Galveston, in 1872 and 1873.

The highest tide occurred September 17, and was $5\frac{2}{10}$ feet above mean low. The lowest tide occurred December 30, and was $3\frac{2}{10}$ feet below mean low, giving $8\frac{5}{10}$ feet as the range for the year. The anemometer records the direction of the wind at the beginning of each hour and the mean velocity for the preceding hour. The wind-curve, therefore, does not show the greatest velocity that the wind may have attained at any time, but the mean velocity for the hour preceding the ordinate at the even hour.

The greatest hourly velocity shown on the chart is 49½ miles. From the 16th to the 18th of September, the anemometer being out of order, the record was obtained from the signal-observer at Galveston.

This curve shows the actual velocity at times of observation, and not the mean hourly velocity, as elsewhere. The greatest velocity attained at that time was 60 miles per hour, on the 17th.

Very respectfully, your obedient servant,

H. C. RIPLEY,
Assistant Engineer.

REPORT OF MR. H. C. RIPLEY, ASSISTANT ENGINEER, ON SURVEY MADE IN JUNE, 1878

* * * * * * *

In accordance with instructions contained in your letter dated New Orleans, La., May 28, 1878, I chartered a sail-boat and proceeded to make surveys of the inner and outer bars, but was unable to do more than complete the inner-bar survey up to the time of resumption of work on the 13th. Since then the delay in getting the steam-launch in running order, and unfavorable weather has rendered it impossible to do anything further. I transmit herewith a tracing of the inner-bar survey, from which it will be seen that a very favorable change has taken place in the channel across the bar since the last survey (October, 1877). There is now a practicable channel across the bar of 20½ feet, with a least width between the 20-foot curves of 200 feet. From the inner end of the gabionnade to Bolivar Channel, across the bar, there is a practicable channel of 22½ feet with a least width between the 20-foot curves of 500 feet. The shoaling just inside of the gabionnade is doubtless caused by the cross-current from the old Swash Channel around the end and through the breaks in the pile-breakwater. Nevertheless, there is a channel-width of 500 feet between the 18-foot curves, which is a gain in width since October of 320 feet.

On the bar proper the 18-foot curves have receded on the west side 1,500 feet and on the east side 600 feet, leaving an opening between them of 4,000.

Between the 20-foot curves the width is 1,900 feet. Along the channel face of the gabionnade the 18-foot curve has straightened and approached the gabionnade; the 12-foot curve has straightened and moved across the older portion of the gabionnade to the channel side and 140 feet beyond.

The 6-foot curve has also crossed beyond the channel-face of the gabionnade, having moved to the westward a distance of 1,140 feet.

A 2-foot shoal has formed on top and back of this portion of the gabionnade, where a similar shoal, though smaller, existed in June, 1877.

Along the newer portion of the gabionnade a deep trench still remains, but it does not extend so far south, but has increased its depth and width. East of this for some 2,000 feet the 18-foot curve has remained constant, the 12-foot curve has moved a little to the north, and the 6-foot curve has moved about 600 feet to the north. West of the channel on the bar, the 12-foot curve has moved west 400 feet and the 6-foot curve about 200 feet. The old Swash Channel has not materially changed, except at its head, where it has much narrowed.

Very respectfully, your obedient servant,

H. C. RIPLEY,
Assistant Engineer.

The results here reported appear sufficiently satisfactory, and may even lead one less sanguine than myself to confidently look for results on the outer bar equally as gratifying as those obtained and maintained over the inner bar.

At this port during the year from June 30, 1877, to June 30, 1878, there was collected $77,869.23, and of this amount the duties on merchandise received in bond amounted to $2,085.75.

Entrances and clearances from June 30, 1877, to June 30, 1878.

Vessels.	Entrances.		Clearances.	
	No.	Tons.	No.	Tons.
American (coast)	199	193, 652	291	271, 264
American (foreign)	37	11, 890	40	18, 197
Foreign	93	60, 695	95	64, 094
Total	329	266, 237	426	353, 555

Value of exports shipped to foreign countries during the year ending December 31, 1877, $13,339,855.

The work is located in the collection-district of Galveston, near the light-house on Boliver Peninsula:

Original estimate	$1,259,446 43
Whole amount appropriated	477,000 00
Whole amount expended	357,662 72

Money statement.

July 1, 1877, amount available	$36,052 60	
Amount appropriated by act approved June 18, 1878	50,000 00	
Amount appropriated by act approved June 7, 1878	75,000 00	
		$161,052 60
July 1, 1878, amount expended during fiscal year	37,089 60	
July 1, 1878, outstanding liabilities	4,625 72	
		41,715 32
July 1, 1878, amount available		119,337 28
Amount (estimated) required for completion of existing project		82,740 00
Amount that can be profitably expended in fiscal year ending June 30, 1880*		150,000 00

J 3.

IMPROVEMENT OF SHIP CHANNEL IN GALVESTON BAY, TEXAS, BETWEEN BOLIVER CHANNEL AND RED FISH BAR.

For reasons fully set forth in the report of the Chief of Engineers for 1877, pp. 455 to 458, this work was held to await further action of Congress, and no expenditure was made from the appropriation of 1876.

Under the combined appropriations of 1876 and 1878, and in accordance with the act of Congress cited above, it is proposed during the present year to, as nearly as possible, complete by contract a channel 12 feet deep at mean low-tide and 100 feet wide at bottom, in a direct line from the head of Boliver Channel to the United States cut through Red Fish Bar. The width of 100 feet is selected, because the estimate of Mr. H. C. Ripley, assistant engineer, shows that the amounts now available for this work will complete such channel, while it would not complete a channel 150 feet wide. The 100-foot channel will, in a measure, answer the requirements of commerce until means may be provided for making one of a greater and more desirable width.

* The amount required for next fiscal year in excess of balance remaining after deducting total amount appropriated from amount estimated for completion of existing project is necessary to cover loss to the work sustained by frequent suspensions, due to inadequate appropriations.

This will yet leave the channel through the upper bay to be provided for and its location determined by Congress.

The work is located in the collection-district of Galveston, near the light-house on Red Fish Bar.

Whole amount appropriated	$172,000 00
Whole amount expended	25,000 00
Original estimated cost:	
10-foot channel, 150 feet wide	283,479 00
12-foot channel, 150 feet wide	651,562 20
15-foot channel, 150 feet wide	1,260,062 10
Revised estimates:	
*Ripley, 12-foot channel, 100 feet wide	160,994 92
†Hayward 12-foot channel, 100 feet wide	285,331 50
	446,326 42

Money statement.

July 1, 1877, amount available	$72,000 00	
Amount appropriated by act approved June 18, 1878	75,000 00	
		$147,000 00
July 1, 1878, amount available		147,000 00
Amount (estimated) required for completion of existing project, 12 feet deep, 100 feet wide		446,326 42
Amount that can be profitably expended in fiscal year ending June 30, 1880.		200,000 00

REPORT OF BOARD OF ENGINEERS ON PROPOSED SHIP-CHANNEL THROUGH LOWER GALVESTON BAY.

ARMY BUILDING,
New York, September 10, 1877.

GENERAL: The Board of Engineers appointed by Special Order No. 9, dated Headquarters Corps of Engineers, Washington, D. C., January 25, 1874, and re-convened by Special Order No. 95, dated Headquarters Corps of Engineers, Washington, D. C., August 14, 1877, for the purpose of considering the question of location of a proposed ship-channel through Lower Galveston Bay, and its bearing upon the projected improvement in Galveston Harbor, has the honor of reporting as follows:

The Board met on the 1st instant, as specified in the order, and from day to day studied the data presented, arriving at the following conclusions covering the two points submitted for their consideration:

A line from Red Fish Bar to the head of Bolivar Channel would, in the opinion of the Board, be a more advantageous location for the proposed channel than the line from Red Fish Bar passing west of Half-Moon Shoal and terminating at the inner end of Galveston Channel.

The first named would be shorter, with fewer necessary curves (if any) in its course; would require a much smaller amount of dredging in its first construction, and could afterward be maintained at less cost.

The Board are aware of the advantages to navigation by giving a course to the channel straight from its commencement at the head of Bolivar Channel to its termination at Red Fish Bar. An uncertainty, however, which could be removed by a few observations, now exists whether the channel might not be better maintained by giving it a slight departure from a perfectly straight course. Furthermore, it is the opinion of the Board that the harbor of Galveston, as well as the works

*Lower Bay. †Upper Bay to Morgan's Cut.

projected for its improvement, will not be injuriously affected by the ship-channel proposed from the head of Bolivar Channel to Red Fish Bar.

A proposed location west of Half-Moon Shoal, aside from consideration of much greater cost, would interfere with the original project for harbor improvement, inasmuch as it would cross the line along which it was proposed to close in the harbor, leaving open only its entrance from Bolivar Channel and through West Bay. This closure has not yet been decided upon, but may be considered desirable at some time in the future. Further, if the channel be made on this line, it will be a roundabout route for vessels bound direct from the Gulf to Buffalo Bayou and the San Jacinto River, while at the same time it would possess no special advantages to vessels leaving Galveston for these rivers over the line proposed from the head of Bolivar Channel. It is also the opinion of the Board that the portion of such channel from the head of Galveston Harbor to a point opposite the west end of Pelican Island would be more difficult of maintenance than any portion of the other channel.

Respectfully submitted.

Z. B. TOWER,
Colonel of Engineers, Brt. Major-General.
H. G. WRIGHT,
Lieut. Col. of Engineers, Brt. Major-General.
JOHN NEWTON,
Lieut. Col of Engineers, Brt. Major-General.
C. W. HOWELL,
Captain of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers U. S. A.

J 4.

IMPROVEMENT OF SABINE PASS, TEXAS.

As stated in my last annual report, proposals for this work, by contract, were invited July 16, 1877. The bids were opened August 20, 1877, and as it was estimated that the lowest responsible bid received would not complete a channel of the specified depth of 12 feet, all bids were rejected.

The United States dredge-boats formerly employed at the mouth of the Mississippi River being idle, it was decided to detail one of them, the Essayons, to do the work, her record at the mouth of the Mississippi making it appear probable that she would be able to excavate a channel of 20 feet in depth through Sabine Pass Bar at less cost than the lowest responsible bidder proposed to excavate a 12-foot channel. This decision was approved by the Chief of Engineers, and the *Essayons* sent to Sabine Pass November 22, 1877.

The *Essayons*, after about half completing a channel through the bar ranging from 12 to 15 feet in depth, became disabled by the unexpected failure of her boilers. To avoid delay it was concluded to dispatch her mate, the *McAlester*, to relieve the *Essayons*. The *McAlester* was lost on her voyage to Sabine Pass, which made it necessary to repair the *Essayons* for continuance of the work.

Contract was therefore made for supplying the *Essayons* with new boiler-tubes. After considerable delay, the tubes with which the con-

tractor proposed to do the work were received, and found to be totally unfit for the purpose. Much valuable time was lost in endeavoring to procure suitable tubes in this country, when it was found that they were not to be had short of Scotland. They were therefore ordered from that country, with the understanding that they would be delivered about May 15, 1878. They were not, however, delivered until July 13, 1878. After repairing the *Essayons*, enough money from the last appropriation will probably be left for about two months' work.

No material change in the channel excavated by the *Essayons* has been observed, which would seem to warrant the belief that a channel once excavated through the bar will be comparatively permanent, except, perhaps, at the sea end of the channel, where slight shoaling may probably be expected.

Upon recommendation, approved by the Chief of Engineers, the *Essayons*, and other property belonging to the work for "improving the mouth of the Mississippi River," were transferred to that for improving Sabine Pass.

During the next fiscal year it is proposed to continue the work by dredging with the *Essayons* and purchase of supplies in open market.

The work is located in the collection-district of Galveston, near the light-house at the entrance to Sabine Pass.

Whole amount appropriated	$88,000 00
Whole amount expended	45,147 80
Amount appropriated since adoption of present project	30,000 00
Amount expended, same	35,040 34

ORIGINAL ESTIMATES.

For a 12-foot channel	$105,026 00
For a 15-foot channel	176,071 00
For a 20-foot channel	390,317 00

Money statement.

July 1, 1877, amount available	$50,489 42	
Amount appropriated by act approved June 18, 1878	30,000 00	
		$80,489 42
July 1, 1878, amount expended during fiscal year	35,252 02	
July 1, 1878, outstanding liabilities	2,385 20	
		37,637 22
July 1, 1878, amount available		42,852 20
Amount (estimated) required for completion of existing project (20-foot channel)		302,317 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		100,000 00

J 5.

IMPROVEMENT OF THE NARROWS ABOVE ORANGE, ON THE SABINE RIVER, TEXAS, AND DEEPENING THE CHANNEL AT THE MOUTH OF SAID RIVER.

Project for expenditure of the $10,000 available for this work has been submitted to the Chief of Engineers for approval.

The project contemplates dredging, by contract, a channel 5 feet deep at mean low tide and 100 feet wide (or so much thereof as appropriation available will permit) across the bar of the "Middle Pass" of the river

to that depth in Sabine Lake, leaving the improvement of the "Narrows" until Congress may further provide for that work.

The amount now available is $3,033 less than was estimated would be required to excavate the channel above specified, not to speak of the "Narrows," for which work alone it was estimated $18,000 would be required.

The work is not susceptible of permanent completion.

The work is located in the collection-district of Galveston. The nearest light-house is at Sabine Pass.

Whole amount appropriated	$10,000 00

ORIGINAL ESTIMATE.

Work at mouth (page 541, Report 1871)	$38,000 00
Removing snags, &c. (page 680, Report 1873)	18,000 00

Money statement.

Amount appropriated by act approved June 18, 1878	$10,000 00
July 1, 1878, amount available	10,000 00
Amount (estimated) required for completion of existing project	21,033 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.	21,033 00

J 6.

DEEPENING THE CHANNEL AT THE MOUTH OF THE NECHES RIVER, TEXAS, AND REMOVING OBSTRUCTIONS TO BEAUMONT.

Project for expenditure of money appropriated for this work has been submitted to the Chief of Engineers.

As improvement of the river between its mouth and Beaumont is called for in the appropriation act, jointly with improvement of channel across the bar in Sabine Lake, reference is made to the report of latest survey of the river (see Report of Chief of Engineers, 1874, pp. 743–754), where it will be found stated that this portion of the river was then in good navigable condition, and did not require improvement.

In view of this it is proposed to expend the appropriation in making a channel through the bar at the mouth (in Sabine Lake), to have a depth of 5 feet at mean low tide, and a width of 40 feet, or in making so much of said channel as the appropriation of $8,000 will permit.

The work to be offered at contract, and conjointly with that at the mouth of the Sabine River.

It would be desirable now to contract for a channel 100 feet wide instead of only 40 feet, if the appropriation was not deemed insufficient, perhaps, for even completing the latter. The latter, by confining work, if necessary, to the shoaler portions of the bar, will be of benefit to commerce.

A re-examination of this bar, as well as of that at the mouth of the Sabine River, will be made, before advertising the work, in order to ascertain what change, if any, has taken place since date of last surveys.

The work is not susceptible of permanent improvement.

No commercial statistics.

The work is located in the collection-district of Galveston.
The nearest light-house is at Sabine Pass.

Whole amount appropriated	$8,000 00
Original estimate: Work at mouth (part 1, page 743, Annual Report of the Chief of Engineers, 1874)	26,318 05

Money statement.

Amount appropriated by act approved June 18, 1878	$18,000 00
July 1, 1878, amount available	8,000 00
Amount (estimated) required for completion of existing project	18,318 05
Amount that can be profitably expended in fiscal year ending June 30, 1880.	18,318 05

J 7.

DEEPENING THE CHANNEL AT THE MOUTH OF TRINITY RIVER, TEXAS AND REMOVING OBSTRUCTIONS TO LIBERTY.

Project for expenditure of the $10,000 available for this work has been submitted to the Chief of Engineers with recommendation that the work be advertised to be done by contract.

If the small appropriation will admit, it is proposed to dredge a channel 5 feet deep and 100 feet wide across the bar obstructing the entrance to the river.

The original plan for improvement of channel across the bar at the mouth of this river contemplated excavating a channel 6 feet deep and 80 feet wide across the bar obstructing the mouth of the river, the cut to be protected by a pile breakwater. The estimated cost was $40,000.

The estimate for dredging alone was $11,967, or $1,967 more than is now available for the work, coupled with clearing the river up to Liberty.

If it be found that the amount appropriated be not sufficient to excavate the channel to the full width proposed, a lesser width will be adopted, so that the work may be made to partly relieve the commerce of the river; the attainment of a more desirable width and the protection of the channel by means of pile-breakwater, being left to future appropriations.

The improvement of the river from its mouth to Liberty must also be left in the same way.

Before advertising a re-examination will be made, as at the mouths of the Neches and Sabine.

It is proposed to advertise these three works together, in order to attract bidders, all of whom must bring their dredges, scows, and tugs from a distance at an expense which no one work alone would justify, except at a comparatively enormous price per cubic yard for material excavated.

Appropriations for the three works added together foot up $28,000. The works are not far apart, and it is thought that one good dredge should complete the three, so far as appropriation will permit, in about 12 months from time of commencement.

While the three works will be advertised together, and contract made with the lowest responsible bidder for all, the appropriation for each will be kept separate and only applied to the specific work for which made.

The work is not susceptible of permanent completion.

The work is located in the collection-district of Galveston.
Nearest light-house, Red Fish Bar, Galveston Harbor.
No commercial statistics on file since 1873.
Whole amount appropriated, $10,000.

ORIGINAL ESTIMATE.

Work at mouth (page 537, Report 1871)	$40,000 00
Removing snags, &c. (page 685, Report 1873)	6,000 00

Money statement.

Amount appropriated by act approved June 18, 1878	$10,000 00
July 1, 1878, amount available	10,000 00
Amount (estimated) required for completion of existing project	7,967 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.	7,967 00

J 8.

IMPROVEMENT OF PASS CAVALLO, INLET INTO MATAGORDA BAY, TEXAS.

As the appropriation of $20,000, made by the river and harbor act of August 14, 1876, was too small for commencement of operations without risk of great loss, to which an unfinished structure in the exposed locality of this work would have been subjected, it was recommended by the Chief of Engineers that the expenditure of the appropriation be suspended to await future action of Congress. This recommendation was approved by the Hon. Secretary of War. No work, therefore, was performed during the past fiscal year.

Operations during the present fiscal year will depend upon the changes reported to have occurred in the Pass since the last survey.

Authority has been asked from the Chief of Engineers to have an examination made of the Pass to ascertain the nature of the changes, that a project for the judicious expenditure of the money now available may be submitted.

The work is located in the collection-district of Indianola, Tex., and near Matagorda light-house.

Whole amount appropriated	$45,000 00
Original estimate	715,325 00

Money statement.

July 1, 1877, amount available	$20,000 00	
Amount appropriated by act approved June 18, 1878	25,000 00	
		$45,000 00
July 1, 1878, amount available		45,000 00
Amount (estimated) required for completion of existing project		670,325 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		150,000 00

J 9.

REMOVING OBSTRUCTIONS IN BAYOU LAFOURCHE, LOUISIANA.

The act of Congress approved June 18, 1878, appropriated $10,000 for this work, which it is proposed to apply to the removal of stumps and snags between Thibodeauxville and Parr's Canal, as recommended in my report of survey of the Bayou in 1874.

Whole amount appropriated	$10,000 00
Original estimate for removal of snags, &c., page 770, Report 1874	10,000 00

Money statement.

Amount appropriated by act approved June 18, 1878	$10,000 00
July 1, 1878, amount available	10,000 00

J 10.

IMPROVEMENT OF THE HARBOR AT NEW ORLEANS, LOUISIANA.

During the present fiscal year it is proposed to expend the amount available in conducting the work by hired labor and purchase of material in open market, and in the manner recommended in report of the Commission of Engineers recently convened for the purpose of perfecting a plan for protection of the city front and submitting estimates for the same, of which the following is a copy:

REPORT OF COMMISSION OF ENGINEERS.

NEW ORLEANS, LA., *April* 8, 1878.

SIR: The Board of Engineers convened at the request of the city council "to examine and report upon the means necessary to protect the wharves and harbor from the incursions of the river," beg to submit the following:

Referring to your letter of November 17, 1877, the engineering information requested of the Board was as follows:

First. A thorough and complete survey of the river and its banks from the upper to the lower limit of the city, giving cross-sections of the stream every half mile, and the direction of the current.

Second. A plan for the temporary preservation of the banks and wharves from destruction, to apply only to the most exposed points, and adapted to the present resources of the city, which are limited, accompanied by estimates.

Third. A more general and comprehensive plan, embracing the river front of the second and third districts, as a permanent work, with estimates, so as to be commenced and carried on gradually as the future prosperity of the city may admit.

At a former session of the Board, held in November last, a preliminary report was rendered your honor respecting the condition of affairs along the city front. In this the means necessary to be taken to preserve the most exposed points (which were at the foot of Saraparu street and at the foot of Montegut street) were presented, and the execution of the plans was intrusted to and carried out under the direction of the city surveyor. A general plan also was outlined, which was to embrace the entire city front, from Carrollton to a point below the United States Barracks, or so much of it at least as needed permanent protection. The Board were unprepared at that time to decide upon all the details to be observed in this permanent plan of protection, owing to the lack of the necessary information respecting the condition of the caving banks, their extent, their composition, slope, depth of water, &c., all of which could only be furnished by an exhaustive and extensive survey such as called for by your letter.

This survey was undertaken under the personal supervision of the local members of the Board, with aid furnished by the government and by the city, and was carried to a successful termination. It is complete and thorough in all the details necessary for a proper study of the problem submitted to the Board. It extended from a point above Carrollton to a point below the barracks, embracing also the right bank of the river, and was made in three sections. Section first started from a point some 3,300 feet above the Metairie road, at the upper end of a plank revetment where there is a wide batture, and followed the left bank to the Orleans Park, where there is also a wide batture, a total distance of 22,243 feet. At intervals of 100 feet lines of soundings were made extending out from 300 to 400 feet, and where there were caving banks intermediate lines were sounded. Thirty-four sections were also sounded across the river in this stretch, and from 100 to 120 soundings were located on each section. Thirty of these cross-sections were nearly at the same points as those made in the survey of 1851 by Captain (now General) Humphreys. From the Orleans Park to Canal street, there being no caving of the left bank, no survey of that line was made. Section second commenced at Canal street, and the shore-line was run from that point to the slaughter-houses, a distance of 21,800 feet. On this stretch soundings were made at each 100 feet, as before, extending out into the river from 300 to 400 feet. Twenty cross-sections were also sounded at nearly equal intervals, but only about 80 sonndings were located on each one. Section third included the right bank of the river, and commenced at a point 3,450 feet above the lock at Westwego, and extended down to the point at Algiers, and is some 47,000 feet in length. Soundings were made at intervals as in the surveys of the other sections, and 19 cross-sections were sounded across the river between the lower end of the Carrollton section and Canal street, thus filling that interval.

Gauges were kept at Carrollton, Canal street, the mint, and at the United States

Barracks; and all soundings were reduced to the same plane of reference as that of the delta survey, and reads on the Carrollton gauge 15′.70.

The condition of the banks as developed by the survey is as follows:

From the upper end of the Carrollton Survey to station 186 there is a wide batture and no caving going on at present. From station 186 to station 91 (at the head of Carrollton avenue), there is more or less caving of the bank throughout the whole distance. Between stations 140 and 157 some 500 feet of the bank have caved in since 1858, and at the Carrollton Hotel, which is at the lower end of the present cutting, in that time some 200 feet have gone in. The total length of the caving in this section is 9,200 feet.

From station 91 down to station 55 there have been about 200 feet caved in since 1858, but there is little if any caving going on now, except in two places, one about 300 and the other about 200 feet long. Below station 55 there is a fill at present, and a wide batture.

Below Canal street, from Morgan's Wharf, at station 10 to station 160, a distance of 15,000 feet, the bank needs more or less protection. It has, however, only been deemed advisable to apply protective measures to the slope of the bank from Morgan's Wharf to Congress street, a distance of 7,500 feet, leaving the remaining portion of the city below that point to be protected by a new levee.

On the right bank the space through which the caving takes place extends from station 49 to 176, below the locks; and from station 296 to 476, above and at Algiers, a total length of 31,700 feet.

The Board, however, does not deem it at present absolutely necessary to apply the works of protection to this entire stretch of bank, but only to a portion embracing Nine Mile Point.

The locations of the different caving banks at which it is proposed to apply the works of protection can better be understood by reference to the sketch map accompanying the report, while at the same time an inspection of the index and detailed maps will give all the information respecting the depths of water, slope of bank, composition of same, &c., much more fully than can be indicated or enumerated in the report.

The results of the survey of the banks show that they are composed of a hard blue mud with intermediate soft strata. These soft strata outcrop at various depths as shown on adjacent lines of soundings. In some cases they are quite regular; in others, quite irregular, as if deposited upon a slope.

The cavings result from the saturation of these layers of soft material, which are afterward washed or cut out, causing the superincumbent mass to fall or slide into the river. This caving takes place mostly upon a falling river, the high water seeming to act by its pressure in sustaining the bank. These soft strata occur at various depths, from near the surface to near the bottom of the river, and the greater or less amount of cave seems to depend upon their relative position.

In order, then, to retain the bank in its natural position the remedy to be applied would seem to be some method by which the cutting out of the defective strata could be prevented. This is best subserved by applying to the bank a revetment extending so as to cover the whole slope, or so much of it as is likely to be affected.

The banks along the city front present conditions not unfavorable to the successful application of a project such as was outlined in our preliminary report of November last.

The general method indicated there was to cover the slope of the bank with a revetment of brush and stone in such shapes and forms as best suited the particular locality where it was to be applied.

While much more costly applications of timber and stone might subserve the object in view, those of brush and stone in the shape of matting applied to the banks have the merit that, while suitable for the purpose, they are comparatively cheap, are durable, are easily applied, and on account of their pliability can be well adapted to the irregular slopes of the banks caused by the caving. At the same time the carpeting of the bank in such a manner causes no undue contraction of the water-way and allows the current to move along in it natural course.

At the upper section of the river at Carrollton, and on the right bank above Algiers, where there are no wharves, it is proposed, in accordance with the above views, to cover the slopes from a short distance above low-water to a distance out such that all defective strata will be protected by a layer of brush formed into rafts, and ballasted with stone sufficient to keep them in position.

Along the section of the river from Morgan's Wharf to the foot of Congress street it is proposed to form a bulkhead extending the entire distance, in a line with the outer row of wharf-piles, by driving piles in pairs, the distance between the centers of each pair being 6 feet and between the piles of each pair 3 feet. These piles in pairs are bolted together at low water and at the top. Between the piles extending up and down stream brush fascines are piled up to low-water mark, forming, so to speak, a

brush wall. Above low-water mark, on the outside of the piles, plank are placed extending to high-water mark.

From the foot of this row of piles, extending out as far as may be necessary to cover all defective strata, a layer of brush and stone in suitable form is laid upon the slope.

The object in not continuing the revetment clear up to the bank, as in the other districts, is that it has been found from experience that great difficulty and expense will attend the removal of the great number of piles and timber-work now forming the wharves and occupying a portion of the slope needing protection, and which it would be necessary to remove were it determined to carpet the entire slope, adding considerably to the expense, and more than the circumstances would warrant.

Statistics at the disposal of the Board indicate that the largest interests involved are in section 2, from Morgan's Wharf to Congress street. It therefore seems expedient that the proposed measures of protection should be first applied to that part of the shore. Similar reasons indicate that the work on the Carrollton section No. 1 should be next done, and, finally, that work above Nine Mile Point on the right bank which is essential as a protection to the works in section 1 and the shore below.

The following are the estimates for the protection of so much of the city front as the Board deems absolutely essential at the present time to the preservation of the wharves and harbor, though eventually the protection of the entire front may have to be undertaken. These estimates being approximations, the Board has sought to make them sufficiently large to cover all contingencies, leaving to the engineer who may have charge of the construction of the work a certain latitude whereby such changes as may appear necessary, and as circumstances call for, can be made as the work progresses.

ESTIMATES.

Section 2, from Morgan's Wharf to Congress street.

Piles and planking, at $6.33 per running foot	$47,475 00	
Filling between piles, 6,600 cords, at $2.50 per cord	16,500 00	
Brush matting, 7,500 feet long, 200 feet wide in position, and ballasted	146,025 00	
	210,000 00	
Contingencies	25,000 00	
		$235,000 00

Section 1, at Carrollton.

Brush matting, 9,200 feet long, 200 feet wide, sunk and ballasted, at $19.50 per running foot	179,400 00	
Contingencies	18,600 00	
		198,000 00

Section 3, Nine Mile Point.

Brush matting, 2,000 feet long, 200 feet wide, sunk and ballasted, at $19.50 per running foot	39,000 00	
Contingencies	4,000 00	
		43,000 00
Total estimated cost		476,000 00

Herewith are transmitted the drawings* pertaining to the survey, consisting of 4 index charts; 1 sketch map, showing locations of proposed improvements; 2 sectional drawings, showing details of proposed constructions; 43 sheets of drawings, showing details of survey.

There are also transmitted all the papers alluded to in our preliminary report, consisting of letters, views, &c., of professional and other persons in regard to the work.

The Board desire to express their acknowledgment of the valuable services rendered by Commodore C. P. Patterson, Chief of the United States Coast Survey; the officers and crews of the United States men-of-war Enterprise and Canonicus; Messrs. H. C. Collins, W. H. Williams, George d'Hemecourt, M. W. Darton, H. S. Douglass, Eugene Thompson, and Capt. M. W. Francis, and their assistants.

We would respectfully recommend to your honor that provision be made for com-

* Not with the manuscript furnished to the printing-office.—[Printer.]

pleting the maps, &c., of the survey, and the careful preservation of the same as a valuable contribution to the hydrography of the river in the vicinity of New Orleans.

All of which is respectfully submitted.

G. WEITZEL.
W. H. H. BENYAURD.
C. W. HOWELL.
B. M. HARROD.
J. A. D'HEMECOURT.
ROBT. C. WOOD, *Secretary*.

Hon. ED. PILSBURY,
Mayor of New Orleans.

I am not prepared to state whether or not the work is susceptible of permanent completion.

The work is located in the collection-district of New Orleans.
The nearest light-house is at Milneburg, on Lake Pontchartrain.
The nearest light-house on the Mississippi River is at the head of South Pass.

Whole amount appropriated	$50,000 00
Original estimate	476,000 00

Money statement.

Amount appropriated by act approved June 18, 1878	$50,000 00
July 1, 1878, amount available	50,000 00
Amount (estimated) required for completion of existing project	426,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.	200,000 00

APPENDIX K.

ANNUAL REPORT OF CAPTAIN JAMES F. GREGORY, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1878.

UNITED STATES ENGINEER OFFICE,
HEADQUARTERS DEPARTMENT OF TEXAS,
San Antonio, Tex., June 8, 1878.

GENERAL: I have the honor to submit herewith my annual report upon the work for the protection of the river-banks at Fort Brown, Texas, for the fiscal year ending June 30, 1878.

Very respectfully, your obedient servant,

JAMES F. GREGORY,
Captain of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers U. S. A.

PROTECTION OF THE RIVER-BANKS AT FORT BROWN, TEXAS, FROM ENCROACHMENTS OF THE RIO GRANDE.

In my last annual report dated San Antonio, Tex., July 10, 1877 (see Appendix K, to Annual Report of Chief of Engineers for 1877), it was stated that the work contemplated, and approved by the Chief of Engineers, for the protection of the northwest river-front of the Fort Brown inclosure, was finished, and that no further recommendation in regard to it could be made until the effects upon it of the next considerable rise in the river should be known.

Briefly described, the work was a pile-breakwater composed of two rows of 12 by 12 inch piles 40 feet long. These piles were firmly bound together by a double set of longitudinal and transverse braces of 10 by 10 inch timbers bolted on with 1-inch screw-bolts with double washers. The braces were placed as near as possible to the surface of low-water, and the pile-tops were sawed off 1 foot above the top braces; the design being to prevent the deep channel from approaching nearer the shore, and in the belief that, if erosion by the main current could be prevented, the damage caused by the flow of water over the work at periods of high water would be inconsiderable and of small importance compared to the advantage gained by having short leverage against the piles.

The piles were driven, with the exception of the anchorage-piles at the head and foot of the work, from 18 to 29 feet into the ground or river-bottom, being in each case to the extreme limit of endurance of the fiber of the timber.

Under the entire work brush mattresses 1 foot in thickness were placed to prevent washing around the feet of the piles. The axis of the main work was a line starting at the river-bank, at the foot of Fourteenth street, Brownsville, and made an angle of 9 degrees with the general direction of the shore-line from the starting point to a point in front of the Administration Building.

The main work was 170 feet long, and was connected with the bank below by a wing built in the same manner as the main structure, and making with it an angle of about 120 degrees; the object of the wing being to prevent the formation of a dangerous eddy below the work.

Above the head proper of the work a row of ten piles, in prolongation of the outside row of the main work, was driven along the low water shore-line, and these were connected with each other by stringers bolted on as on the main work.

On the 25th of October of last year I received from Maj. W. R. Price, Eighth United States Cavalry, then commanding at Fort Brown, telegraphic information of injury to the breakwater, and also a report of its condition by Mr. S. W. Brooks, who was my overseer on the work during its construction.

The latter reported that the underlying quicksand had been washed away from the bank at and above the head of the work, causing from 2 to 2½ feet in thickness of it to settle from 18 to 20 inches, carrying with it the piles driven in it. The main work was not very much injured, but four or five of the piles being attached to the facing piles had moved slightly.

It appears that the current impinged upon the bank a little above where it did when the work was erected, and it was apprehended, with good grounds, that the current might wash in behind the head of the work and render it worse than useless. I therefore recommended that the unexpended balance of the appropriation, $2,802.41, be re-transferred to me to enable me to render the head of the work secure, and asked authority to employ an assistant to superintend the work of repairs.

By letter of the Chief of Engineers, dated Washington, D. C., November 6, 1877, my recommendations were approved, and I was authorized to proceed with the work of repairs by purchase of material and hired labor.

The timber, machinery, and materials were purchased in Galveston, Tex., and shipped by schooner to Brazos de Santiago and thence by rail to Brownsville.

The services of Mr. S. W. Brooks were secured, and under his superintendence the new work was begun on the 1st of March and completed on the 15th of May.

The work performed consisted in removing the facing piles which were now useless, and commencing at the sixth pile of the main work, continuing a new work upon the same plan as the old one about 130 feet farther up the stream, the last 40 feet of this distance being sheet piling.

There were driven twenty-three large piles from 22 to 28 feet into the ground (after piles had settled through the mattresses and into the mud of the river bottom by their own weight and that of the hammer resting upon them) by from 70 to 120 blows with a hammer weighing 1,300 pounds, falling from a minimum height of 10 feet and a maximum height of 40 feet.

The whole was braced and ballasted as was the main structure, and the space between it and the river-bank filled with condemned hay, ballasted with brick-bats and covered with earth.

At the foot of Fourteenth street, Brownsville, a new sewer-outlet was constructed across the work, thereby pouring the sewer-floods into the river outside of the work. This sewer was partially the cause of the damage to the original work. Some delays in the progress of the work were caused by sudden temporary rises in the river, but everything was in complete order, when, on May 15, the river suddenly rose to a height

12 feet above low-water surface. It as suddenly fell to 6 feet above w-water, and then rose again slightly.

Mr. Brooks reports to me that, upon the subsidence of high-water, not ly had the work sustained no damage, but that a considerable amount sediment had been deposited upon and behind it, and that it has every ppearance of being thoroughly substantial.

There have been several considerable changes in the conditions of the roblem of protecting the post front since my examination of last year. he Mexican point known as Santa Cruz Point, opposite Brownsville, as been eroded somewhat, and this action still continues. In the elbow f the river just above the breakwater quite a flat of sand has been deosited, and between the pumping-house of the garrison and Old Fort rown a large flat has been deposited.

The Levee Company of Brqwnsville have this spring put in a small tty of live willow piles just above the city, at an expense probably of bout $3,000, which also stood well the effects of the last rise. It is too arly to say, however, what probable effect upon the river-channel this tter work will have, but I do not anticipate from it any special result ther detrimental or beneficial to the front of Fort Brown.

In front of the Administration Building, and a little lower down, the ank is being eroded quite rapidly, about 5 feet having gone since last ear, and danger is still to be apprehended for said building and lest ie river yet break through into the lagoon.

As the breakwater proper erected last year has stood perfectly during ie rises of last year and the high water this year, I would respectfully ecommend that it be extended upon the same plan 400 feet further own the river, which would probably perfectly protect the garrison ont.

The cost of the original structure and wing at lower extremity, 200 et in length, was $7,197.59. To build 400 feet extension would therefore cost $14,400, and I respectfully recommend that said amount be ppropriated for the purpose.

The following is a statement of funds showing the amounts expended uring the fiscal year ending June 30, 1878, and the amount available uly 1, 1878:

Money statement.

uly 1, 1878, balance available of appropriation made by Sundry Civil act approved July 31, 1876	2,802 41
uly 1, 1878, amount expended during fiscal year	2,796 33
uly 1, 1878, amount available	6 08
mount that can be profitably expended in fiscal year ending June 30, 1880.	$14,400 00

APPENDIX L.

ANNUAL REPORT OF CAPTAIN W. H. H. BENYAURD, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1878.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., July 1, 1878.

GENERAL: I have the honor to transmit herewith annual reports upon the different works under my charge, for the fiscal year ending June 30, 1878.

Very respectfully, your obedient servant,

W. H. H. BENYAURD,
Captain of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers U. S. A.

L 1.

IMPROVEMENT OF THE OUACHITA RIVER, ARKANSAS AND LOUISIANA.

The project for the improvement of the Ouachita when I assumed charge of the work contemplated the construction of a series of locks and dams for slack-water navigation. For sufficient reasons this idea was abandoned, and operations afterward confined principally to the removal from the river of all obstructions interrupting navigation, consisting of wrecks, snags, sunken logs, leaning trees, &c., using for this purpose the light-draught snag-boat O. G. Wagner.

These operations have been carried on for the past three years, greatly to the benefit of the navigation of the river.

At low-water stages in the Ouachita but a comparatively small quantity of water passes Camden, rendering navigation to that point exceedingly difficult, especially over the shoal places. To ameliorate this condition of affairs, it was proposed at the commencement of last season's work to build at the various shoal places in the upper river wing-dams of brush and stone for the purpose of concentrating all the water, when at a low stage, in a single channel of sufficient width for all navigation purposes. Accordingly work was inaugurated at Spoon Camp Shoals, and dams were built at that place, and also at Buffalo Flats, four in all. They have greatly benefited the low-water navigation of these shoals, which were considered the worst in the upper river. The success attending this project, as testified to by the steamboat-men, induces me to try other dams at various points below, notably at Hog-Eye Shoals, Slim Island, and Smack Over Shoals in Arkansas.

Operations will be continued with the *Wagner* to the extent of the funds appropriated, in the above work, and also in the removal of snags, logs, &c., forming obstructions to the navigation of the river.

The report of Mr. Justin Straszer, upon the last season's work on the dams and upon the removal of obstructions, is submitted below.

UNITED STATES SNAG-BOAT O. G. WAGNER.
Memphis, Tenn., November 30, 1877.

MAJOR: I have the honor to submit herewith my report on the operations of the United States snag-boat O. G. Wagner in the Ouachita River, from July 1 to November 9, 1877.

* * * * * * *

The project for the improvement of navigation in Ouachita River for the summer season of 1877 embraced as the most important object the construction of low-water dams at Spoon Camp Shoals and Buffalo Flats, in the State of Arkansas, for the purpose of concentrating the water, when at a low stage, in one single channel at each of these places.

Work at Spoon Camp Shoals had already been started June 18, 1877. I concluded to select as the future channel the cut-off across the point next to the right shore, and to concentrate all the water in the same, closing the former low-water channel and a minor chute formed between the island and a tow-head.

Two dams were constructed for that purpose. Dam No. 1 reaching from the main left bank of the river to the tow-head situated between it and the island. Dam No. 2 was thrown across the smaller chute from the tow-head to the island.

Dam No. 1 is 110 feet, dam No. 2, 90 feet long; both have a base of 50 feet, and are carried to a height of 5 feet above low water.

The material used in the construction of the dams consisted of willow brush, manufactured into mattresses, and ballasted with sand-sacks, rock, and heavy water-logged timber, principally oak and gum.

These mattresses rested on the lower side against a row of piles, driven with a pile-driver, which I set up on the bow of the snag-boat, using the machinery of the hoisting-crane for lifting the hammer.

The aforementioned water-logged timber were snags and logs lying at the bottom of the river above the shoals; and as it was required to have them taken out at any rate, they were carried on the boat to the site of the dam, placed in proper position, and thus used with great advantage as ballast.

The intervals between these layers of logs were filled up with willow brush, sand-sacks, and rock, and the dams thus carried with alternate layers to a height of 5 feet above low water.

Even during the building of the dams a marked improvement could be observed in the cut-off which was destined to be the future low-water channel; at the same time the pools above and below the dams, in the old channels, commenced to become shallow and fill up.

On the 25th of June a sudden rise, to a height of 6 feet over the nearly finished dams at Spoon Camp interrupted work at that locality for several days, during which time I collected and towed material to Buffalo Flats for building the dams at that place. After the rise had subsided work was resumed at Spoon Camp. Both dams were found solid and intact; the upper pool had filled up to such an extent that when taking the last load of rock to the upper side of dam No. 1 the boat could be managed only with difficulty in the shallow water, the wheel plowing up the new deposits; the same effect took place in the pool below the dams.

I finished work at Spoon Camp July 5, and proceeded to Buffalo Flats on the same day.

At Buffalo Flats 2 dams were constructed in the same manner; the principal dam, to close the chute between the right bank and the island, having a length of 75 feet by a base of 40 feet, and carried to a height of 5 feet above low-water; the second dam at this locality reaches from the right bank to the tow-head opposite the mouth of Locust Bayou at the head of the shoals of Buffalo Flats. Both of these dams were constructed and finished by July 11.

While this improvement at Buffalo Flats will be of great help to navigation at a low stage, these shoals could be further improved materially by building a wing-dam on the left shore, 600 feet long, which would be the means of straightening the crooked channel at the lower end of the shoals; this work, however, could not be undertaken, as the river was falling rapidly above Camden, and was expected to be soon to low-water mark above the overflow region.

As several important obstructions existed in the channel between Buffalo Flats and Wilmington which were required to be removed, I proceeded downstream and engaged on that work, likewise on cutting some leaning timber at different points where it was considered most necessary.

I found snags most numerous at Haidee Shoals and above and below Eldorado Landing; also very dangerous isolated snags in different localities, which were removed on the trip downstream.

Thus, operations were carried on until the 17th of July, on which day I reached Moro Bay. While at Moro, I received information through pilots concerning the stage of water in the lower river, which was still influenced by the backwater of Mississippi River, reaching as high as Carryville at the head of the overflow region.

Thus not seeing any prospect of being able to continue operations in removing snags for at least six weeks, I proceeded to Monroe, La., and reported to you the circumstances, recommending at the same time to withdraw the snag-boat O. G. Wagner from Ouachita for the present, and change her field of operations to Yazoo River.

My programme having been approved, I started, pursuant to your orders, from Monroe, La., to Yazoo River, arriving at Vicksburg July 27, 1877.

The summary of work in Ouachita River from June 18 to July 17 comprises the following items:

Construction of 4 low-water dams at Spoon Camp Shoals and Buffalo Flats.

Removal of 85 snags and logs from the channel between Camden and Wilmington.

Cutting down 191 leaning trees.

While since the inauguration of improving navigation in Ouachita River a great amount of work has been done towards accomplishing the object, it will nevertheless be necessary to continue these operations every year. Obstructions to navigation will form every year after the freshets, trees will cave in from the banks, and reach in many instances across the channel in low-water navigation, making the passage of boats not only dangerous, but are also a great source of trouble, causing delay and detention. If allowed to remain long, drift will settle on the same, forming wrack-heaps and sand-bars, which would not take place by removing the source of it in proper time.

Low-water dams, similar to those constructed at Spoon Camp Shoals, would be of great benefit to navigation at the following localities in Arkansas: Hog-Eye Shoals above Miller's Bluffs, Slim Island Shoals, Smack Over Shoals.

In the State of Louisiana the following places are recommended to receive early attention, viz: Removal of land-slides between Trinity and Harrisonburg; Catahoula Shoals; land-slides at Columbia; Rutland Bar; removal of wreck of steamer Dr. Batey; Rock Row Shoals; Rock Ledge below Mrs. Sterling's plantation; also removal of logs and snags in different localities between Monroe and Trinity which have accumulated and floated in during the past two seasons.

* * * * * * *

Very respectfully, your obedient servant,

JUSTIN STRASZER,
Commanding United States Snag-boat O. G. Wagner.

Maj. W. H. H. BENYAURD,
Captain, Corps of Engineers, U. S. A.

The snag-boat being the only light-draught one in service, I have been compelled to take her from the Ouachita from time to time and use her on other streams; for instance, the Yazoo River, Mississippi, where the appropriation was not sufficient to provide an outfit and at the same time do any work. For this reason I have usually asked for less appropriation than would keep the *Wagner* a whole season upon the Ouachita, where she might possibly work to better advantage.

COMMERCIAL STATISTICS.

Ouachita River and its tributaries were navigated from July 1, 1877, to May 30, 1878, by 12 steamers of the regular line and by 7 independent steamers.

The total number of bales of cotton carried by these boats is 131,324, valued at	$6,566,200 00
Value of up-freight, consisting of—	
Provisions, supplies, &c., from New Orleans direct	4,496,340 00
Provisions from Saint Louis, re-shipped at mouth of Red River	100,000 00
	4,596,340 00
Miscellaneous down-freight:	
656,620 sacks cotton-seed	393,972 00
1,000 head of cattle, at $19	19,000 00
1,500 head of hogs, at $6	9,000 00
200,000 white-oak staves	20,000 00
Total value	11,604,512 00

The Ouachita is in the collection-district of Arkansas, there being but one, and in the third collection-district of Louisiana.

The port of entry properly is New Orleans, La.

The amount of revenue collected at that place is..... $1,475,780 35

The original estimate of operating upon the Ouachita with snag-boat is as follows:

Cost of steamer	$30,000 00
Running expenses per month	2,200 00

No detailed estimates will be presented for the improvement of the Ouachita with the snag-boat, since the nature of the work must be continuous from year to year, owing to the character of the obstructions which each flood brings down.

The estimates are, therefore, only based upon the amount required to run the snag-boat for a season's work.

Amount appropriated March 3, 1871	$51,000 00
Amount appropriated June 10, 1872	100,000 00
Amount appropriated March 3, 1873	60,000 00
Amount appropriated August 14, 1876	12,000 00
Amount appropriated June 18, 1878	10,000 00
Total amount appropriated	233,000 00
Total amount expended	222,977 68
Balance on hand July 1, 1878	10,022 32

The first appropriation were made with a view to the improvement of the river by means of a system of locks and dams, the estimated cost of which was $1,163,083.75, and by operating with a non-propelling crane-boat.

There had been expended under this project for materials, surveys, &c., about $160,000 when it was abandoned.

The remainder of the appropriations has been expended in the purchase of an iron-hull snag-boat and in operating it upon the river.

Money statement.

July 1, 1877, amount available	$6,830 56	
Amount appropriated by act approved June 18, 1878	10,000 00	
		$16,830 56
July 1, 1878, amount expended during fiscal year		6,808 24
July 1, 1878, amount available		10,022 32
Amount that can be profitably expended in fiscal year ending June 30, 1880		25,000 00

L 2.

IMPROVEMENT OF THE YAZOO RIVER, MISSISSIPPI.

Operations upon this river were carried on by the snag-boat O. G. Wagner, at such times as she could be spared from the Ouachita, in removing snags, sunken logs, and also the wrecks of various steamers sunk during the late war.

The original detailed estimate for the improvement of the Yazoo River was $120,000, which included the cost of a snag-boat to be used especially upon this river. The appropriations, however, have usually been too small for this purpose and also to bear the operating expenses of a season's work, and I have, therefore, been compelled to use the *Wagner*

at such times as I could get her. It was only in this way that any progress could be made toward the improvement of the river.

The report of Mr. Justin Straszer, giving the operations for last season, is submitted below:

UNITED STATES SNAG-BOAT O. G. WAGNER,
Memphis, Tenn., November 30, 1877.

MAJOR: I have the honor to submit herewith my report on the operations of the United States snag-boat O. G. Wagner in the Yazoo River from July 1 to November 9, 1877.

* * * * * * *

Before entering upon the duties of removing obstructions to navigation in Yazoo River, I had a consultation with the most prominent captains and pilots navigating that river, with the view to ascertain their wishes regarding the removal of the same. These obstructions, consisting principally of logs, stumps, and wrecks lying at the bottom of the river, in or near the edge of the channel, are very numerous; and, as the season for working in Yazoo River is comparatively very short, it was deemed advisable to select first the most dangerous obstructions, and leave the removal of the others to future time.

Accordingly, a list of the most prominent obstructions and their localities was made out and handed to me. In order to carry out this programme, I decided to regulate the movements of the snag-boat with the fluctuations of the stage of water in the river. Hence the whole distance from the mouth of the river to Greenwood was visited twice up and down, several localities oftener to secure the removal of certain obstructions, whenever circumstances compelled me to postpone work at such places to a more favorable time.

Guided by this programme, I started from Vicksburg on July 29 and commenced active operations the next day.

Thus moving up-stream, work was carried on successfully until the 20th of August, when sickness commenced to set in among the officers and deck-crew to an alarming extent, most of the cases being malarial fevers, some of them of very critical type, which compelled me to abandon work at Caldwell's Point, and proceed to Greenwood for the purpose of removing the sick people to houses and under the care of skilled physicians.

Having recruited my force, I returned from Greenwood, working down-stream, carrying on the operations until September 10, when renewed sickness among the employés caused considerable delay in the execution of the work. By your letter, dated Memphis, August 29, in response to my report on the previous cases of sickness, I was authorized to lay the boat temporarily up. I therefore thought best to suspend operations until later in the season, when the work could be carried on without danger of injuring the health or sacrificing the lives of the employés. Accordingly, I started for Vicksburg, where I arrived September 12. A portion of the crew was discharged, while the mechanics, such as engineers, carpenters, and mates, with a few men, were engaged in repairing damages to machinery, patching up deck, and fitting up new iron nosing, all of which work was completed by September 22.

The most excessive heat of the summer having passed, and not anticipating any further danger to the health of the employés, I shipped again the full crew of the boat and started from Vicksburg on the 24th of September to resume operations in Yazoo River.

I worked again up-stream, and the stage of water being much lower than during the first cruise, I was enabled to remove now such obstructions as I had to pass over during the first trip up and return.

Operations were carried again as high as French Bend and back to the mouth of Little Sunflower River, until the 7th day of November, when I received your instructions to withdraw the snag-boat from Yazoo River and proceed with her to your headquarters at Memphis, Tenn.

The obstructions were especially prominent in the following-named localities: From Collin's Bayou to the mouth of Little Sunflower River, notably at Brown's Bar; Eldorado and Belcher's Bar; in the narrows above mouth of Big Sunflower; from Liverpool to O'Neal's Creek; Short Creek Shoals: Wolf Lake Landing and Tuscola; in bend at Lousy Level and above Randall's Landing; in the Ox Bows; from Huntsfield to Rosebank, a distance of 10 miles, including Gold-dust Bend, Eagle Lake Bend, Ship's Bend, to the head of Honey Island; Caldwell's Point, French Bend; bend above Erskin's Landing; Pleasant View, Philipston; also a great number of dangerous single obstructions in different places.

Work throughout was very heavy, especially in the upper river where certain logs and snags could only be removed with the aid of heavy purchase-blocks rigged up on shore. Other obstructions like the cypress stumps at Lousy Level and at Randall's in the Ox Bows, and also prominent logs half-way buried in the bottom of the river, could only be removed with the aid of the diving apparatus and appliances of powder.

The number of snags, logs, and stumps destroyed and removed from the channel during the present season amounts to 612.

The wrecking operations were confined to the following objects:

Wreck of sunken coal-flat above the mouth of Little Sunflower River, removed entirely.

Portion of the wreck of steamer Paul Pry, so much of it as was considered in the way; likewise portion of the wreck of steamer Freestone below the mouth of Piney Creek.

Shaft of steamer Peytona above Kealunsa plantation.

The number of overhanging trees cut down amounts to 576.

Operations in Yazoo River should be carried on in the same manner during the next season. While great improvements have been made, much remains to be done yet, principally cutting leaning trees, and such timber on the banks liable to cave in, in the course of a few years.

Among the old steamboat wrecks still remaining in the river, I consider as the worst the wreck of the Mary E. Keane, lying at the foot of French Bend; the bar opposite the wreck is advancing very far out, narrowing the channel between it and the wreck considerably, and making the passage of boats on dark nights very dangerous.

I am pleased to state that the parties engaged in the navigation of Yazoo River have expressed their entire satisfaction with the successful operations of the snag-boat O. G. Wagner during the past season.

Very respectfully, your obedient servant,

JUSTIN STRASZER,
Commanding United States Snag-boat O. G. Wagner.

Maj. W. H. H. BENYAURD,
Captain Corps of Engineers, U. S. A.

During the coming season it is proposed to use the Wagner in continuing the removal of all obstructions in the river.

The amounts appropriated for the Yazoo have been as follows:

By act approved March 3, 1873	$40,000 00
(This amount was applied to the removal of the wrecks of the steamers Arcadia, R. J. Lackland, Golden Age, Glyde, Petrel, Ivy, Van Dorn, Polk, and Idaho, sunk in the stream during the operations of the war.)	
By act approved March 3, 1875	12,000 00
By act approved August 14, 1876	15,000 00
By act approved June 18, 1878	25,000 00

As stated before, the appropriations are not sufficient to provide an outfit and do the necessary work at the same time.

The Wagner being the only light-draught snag-boat in service, she has many calls made for her services in other of the Southern streams. It is therefore impossible for her to do ample justice to all. It would therefore be well for us to be provided with one other such boat, and I would respectfully recommend that it be provided out of funds hereafter appropriated for the Yazoo.

COMMERCIAL STATISTICS.

The Yazoo River was navigated during the fiscal year by the steamers belonging to the Mississippi and Yazoo River Packet Company, and during a few of the winter months by one independent steamer.

The amount of freight carried during the year is as follows:

101,725 bales cotton, valued at	$5,086,250 00
7,500 tons cotton-seed, valued at	90,000 00
Hides and sundries, valued at	50,000 00
Value of up-freight, consisting of provisions, supplies, agricultural implements, and general merchandise	2,500,000 00
Total	7,726,250 00

Yazoo River is in the collection-district of Vicksburg, Miss. The port of entry is New Orleans, La.

Money statement.

July 1, 1877, amount available	$13,956 51	
Amount appropriated by act approved June 18, 1878	25,000 00	
		$38,956 51
July 1, 1878, amount expended during fiscal year		13,799 68
July 1, 1878, amount available		25,156 83
Amount (estimated) required for completion of existing project		68,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880		50,000 00

L 3.

REMOVING RAFT IN RED RIVER AND CLOSING TONE'S BAYOU, LOUISIANA.

Until within the past two years, the improvements made under the above heads were separate, but they are now continued under one appropriation and allotments made from each as the nature and extent of the work demanded.

REMOVAL OF RAFT IN RED RIVER, LOUISIANA.

At the commencement of the fiscal year the funds on hand for this work and Tone's Bayou amounted to only $2,262.32. At this time the steamer Florence was sunk in Cypress Bayou, whither she had been sent to assist in raising the dredge-boat belonging to that work, and it was proposed to reserve the above amount for the purpose of raising the *Florence*, and repair all damages and to take care of the large quantity of government property, consisting of steamers, crane-boat, &c., lying at Shreveport.

The raft region about this time became blocked with drift, and after the *Florence* was raised I was directed by your telegram of November 10 to expend the balance of the appropriation available to the removal of the jam, and to submit an estimate of funds required to keep the river open for the remainder of the season and to take care of the property. Accordingly the *Florence* resumed work, and removed the obstructions at Gilmer's, raft No. 1, raft No. 5, at Nitro-Glycerine Camp, and at Shady Grove, leaving the river entirely clear.

The funds being exhausted, the whole fleet was laid up and the crew discharged, the captain and two watchmen remaining, however, to take care of the property, though without compensation.

On the 7th of February, 1878, an appropriation of $6,000 was made for the purpose of continuing the work, and operations were commenced and continued at intervals, according to the necessity existing, until the close of the year. The funds were not sufficient to keep the entire force the whole time, the boats being merely taken out only as the emergency existed. At all other times they were laid up and the crews discharged, keeping only sufficient force to take care of the property and to get ready to move upon short notice.

The *Florence* worked during the half of the month of March, and in May and June, keeping the river open and accomplishing the following amount of work:

Removed 13 jams, including parts of old raft formation, 3,775 square yards.
Removed 21 shore-jams.
Pulled 20 snags.
Cut 38 trees on caving banks.
Girdled 83 trees.
Excavated 410 cubic yards of sand and clay from Gilmer's Tow-head.

Capt. J. S. Tennyson was in charge of work the whole time.

The appropriations made have only been sufficient to keep the *Florence* at the above work of keeping the river free from drift, without attending to the removal of certain portions of the old raft still remaining, and which would greatly benefit the navigation of the upper river. It had also been my intention, if sufficient funds were appropriated, to cut off all the trees along the banks as far up as we could go, thus lessening the amount of timber likely to fall into the river, and by this means lessen from year to year the recurrence of jams and the blockage of the river. In my report for the fiscal year ending June 30, 1876, I estimated for this entire work $150,000.

The original detailed estimate for the removal of the raft (see my report for fiscal year ending June 30, 1876; also previous reports of Captain Howell) was $259,014, with additional items for keeping open the channel for first year, $50,000, and for subsequent years it was estimated that from $10,000 to $25,000 would be required.

The amounts appropriated heretofore are as follows:

By act approved June 10, 1872	$150,000 00
By act approved March 3, 1873	50,000 00
By act approved June 23, 1874	50,000 00
By act approved March 3, 1875	20,000 00
By act approved August 14, 1876, for removing raft and closing Tone's Bayou	35,000 00
By allotment August 27, 1877, for closing Tone's Bayou	4,500 00
By act approved February 7, 1878, for removing raft	6,000 00
By act approved June 18, 1878, for removing raft and closing Tone's Bayou	24,000 00

CLOSING TONE'S BAYOU, LOUISIANA.

This work was resumed by me the previous year with an allotment of $25,000 from the combined appropriation, and the mattress-work with which it was proposed to close the bayou carried up to within about 14 feet of extreme high-water mark. At this point the work was left, the funds being insufficient to completely effect the object in view. The dam withstood well the succeeding very high water of Red River, but, as I feared, a portion of the left bank caved in, leaving a gap around that end, the other end and the whole dam remaining intact. There being no funds on hand available, it was impossible to do anything toward repairing the break.

This condition of affairs being reported to the department, and the urgent necessity that existed for immediate action being known, an allotment of $4,500 was made with which to continue the work. The citizens of New Orleans, and others interested in the navigation of Red River, also subscribed $3,000, and with these two amounts of money I commenced immediately to repair all damage.

The end of the dam was secured, and work carried on also upon the dam proper, which was raised several more feet, and the bank below was secured from scour.

An examination of the dam, made some two weeks ago, reports the work in good condition, the flood of this spring having as yet caused no damage.

With an allotment from the appropriation made June 18, 1878, it is proposed to carry up the dam to its full height (extreme high-water mark), and to cover the top with a heavy layer of stone.

It is absolutely necessary that this work be finished, otherwise, as stated in previous reports and letters, the low-water navigation of Red River will be eventually ruined, since Tone's Bayou previous to the commencement of our work was enlarging from year to year, and threatened at no great length of time to eventually absorb all the water of Red River when at its lowest stage.

The report of Mr. Joseph Burney upon the work carried on this season with the allotment of $4,500, and with the funds subscribed by the citizens of New Orleans, is given below.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., January 23, 1878.

MAJOR: I have the honor to report that in accordance with your instructions received in September, 1877, I proceeded to Tone's Bayou, Louisiana, and assumed charge of the work of closing the wash around the east end of Tone's Bayou Dam, and the further strengthening of the works, and respectfully submit the following report of operations:

Before commencing the work, I made a careful examination of Red River near the entrance to the bayou, also of the bayou above and below the dam. I found very little change in the sand-bar in Red River, which was forcing the water down the bayou, nor had Red River below the bayou scoured out much. The mouth of Tone's Bayou, which was steadily enlarging before the dam was constructed, had ceased, and from soundings taken across the mouth showed a very large deposit.

Before commencing upon the dam in 1876, the soundings ranged from 20 to 26 feet, while the soundings taken in September, 1877, showed the greatest depth to be 12 feet, and that only in one place. The other soundings showed 8, 9, 10, and 11 feet, and in one place only 6 feet, thus showing that the bayou was accommodating itself to the greatly decreased discharge of water caused by the dam. The soundings down the bayou, after passing the new bar, did not show much change, while the banks before, which had been steadily caving, had entirely ceased, and in many instances had slightly silted up, on which had sprung up a young growth of cottonwoods. Soundings 900 feet above the dam showed greatest depth to be 20 feet; 800 feet above, 21 feet; 700 feet, 22 feet; 600 feet, 23 feet; 500 feet, 23 feet; 400 feet, 28 feet; 300 feet, 26 feet; 200 feet, 27 feet; 100 feet, 26 feet. Deepest water on crest of dam, 6 feet; least depth, 2 feet.

The dam on west bank was in good condition, showing no danger of a wash around, the sand having filled up both above and below. On the center of the dam a portion had been carried away by heavy drift, and on the east bank a wash around had been made 60 feet wide and 8 feet deep. This bank is composed to a great extent of yellow sand, which readily scours out if not thoroughly protected.

Below the dam very great changes had occurred. On the east bank it had caved for a length of 700 feet, and extended back in some places 130 feet, carrying away over 1½ acres of land. On the west bank it had caved for a length of 500 feet and extended back 200 feet, carrying away three-quarters of an acre, while the soundings below the dam showed a very heavy scour.

Before the dam was constructed the soundings were from 24 to 26 feet, while the soundings taken at the time of examination, 100 feet below the dam, were 41 feet; 200 feet below, 45 feet; 300 feet below, 40 feet; 400 feet, 49 feet; 500 feet, 36 feet; 600 feet, 22 feet; 700 feet, 17 feet; 800 feet, 17 feet.

In September you visited the works and gave instructions respecting the same, which I at once began to execute. The steam-tug Gussie and several flat-boats were chartered and a working party sent 10 miles above Shreveport to obtain willows, which had to be carried to the dam a distance of 35 miles. Another working party commenced work at the dam. The old mattress-ways were repaired, and we commenced the construction of mattresses in the same manner as described in my last report, but not of such large dimensions, being 25 feet by 25 feet by 3 feet. Eight of these were run into and sunk in the chute. Upon the foundation thus obtained we commenced building mattress-work, and by the end of September, 1877, the dam was closed above low-water, closing up 450 square feet of water-area. You again visited the works, and saw the necessity of protecting the ends of the dam above low-water, or the bank would readily cut out the next high-water season.

Work was continued in carrying up each side of the dam and the center closed in to 80 feet. This has an average depth of 4 feet, giving area of discharge 320 feet. Before the dam was constructed the area of discharge was 3,100 square feet.

Before finishing the work the water began to rise rapidly, bringing down from the upper river great quantities of heavy drift-logs, and but for the opening in the center of the dam, which gave them a free outlet, would have seriously injured the work.

I found that sand-bags used above low-water were of little or no use for ballast, as in a very short time they rotted, and the water easily carried off the material with which they were filled. According to your instructions, I endeavored to obtain stone, but found it could only be had above Shreveport, and then only during high-water. We tried rough boxes and barrels filled with clay. This was found much better than sand-bags, but I believe not sufficient to stand the heavy drift-logs; and I think some of the upper works will be damaged for want of a good covering of heavy stone ballast.

Work was suspended November 7, 1877.

Reviewing the work of the past two seasons, it may be considered that it was not so successful as might have been expected. Yet, taking the surrounding circumstances into consideration, I believe they have met with very fair success.

When Tone's Bayou was much smaller than at present, four attempts were made to close it by able engineers, and the first moderate high-water swept them entirely away. In 1876 I had the honor to be placed in local charge of the work. It was late in the season, and I believe the work would have been postponed to you until the following year, but for the urgent request of steamboat-owners and the threatened interruption of navigation to Shreveport during the busiest part of the cotton season.

There was no time to make a thorough preparation, which a work of this importance demands, and we had to construct the dam with what we could find in the immediate neighborhood, viz. cotton-wood-trees, willows, and a very inferior kind of earth-work for ballast, three-fourths of which was carried away by the current. Had there been time to obtain stone, which can only be obtained during high-water, the work would have been far more substantial and economically executed.

In the spring of 1877 a wash was discovered around the east end of the dam, and had there been funds for the work it could have been readily stopped, but it was left to wash out until the beginning of September.

Notwithstanding these difficulties the dam has stood one high-water and two low-water seasons. During the two latter it has thrown back into the main channel nine-tenths of the water which would have been wasted down the bayou and through the lakes.

The water has been over the dam, it has washed around one end, has scoured out an additional depth below of 20 feet, and carried away on the banks below over 2½ acres, yet with the slight damage above described it still remains.

To make the dam permanent much remains to be done. I believe the upper works will be considerably damaged for want of proper ballast; this should be repaired and the whole work receive a heavy covering of stone ballast, and the banks below, so far as the caving occurs, should be protected by mattresses. This work I estimate can be done for $25,000.

I have the honor to remain, very respectfully. JOSEPH BURNEY.

Maj. W. H. H. BENYAURD,
Captain Corps of Engineers, U. S. A.

The above works are situated in the third collection-district of Louisiana.

There is no light-house near them.

The nearest port of entry is New Orleans, La., of which the following statistics for the fiscal year ending June 30, 1878, are given:

Total value of imports	$11,140,170 00
Total value of exports, domestic	85,410,884 00
Total value of exports, foreign	219,475 00
	85,630,359 00
Total amount of revenue collected on imports	1,475,780 35

The following are the commercial statistics of Red River to June 30, 1878:

Bales of cotton	193,000
Head of cattle	23,000
Sacks of cotton-seed	160,000
Sacks of cotton-seed, cake, and meal	38,000
Barrels of cotton-seed oil	5,500

To this should be added the transportation of a large amount of freight up the river, consisting of merchandise, supplies, farm implements, &c., estimated to be one-fourth more than the value of cotton which reaches Shreveport.

Money statement.

July 1, 1877, amount available	$2,262 32	
Amount allotted for Tone's Bayou, August 27, 1877	4,500 00	
Amount appropriated by act approved February 7, 1878	6,000 00	
Amount appropriated by act approved June 18, 1878	24,000 00	
		$36,762 32
July 1, 1878, amount expended during fiscal year { on raft-work	5,509 30	10,316 38
on Tone's Bayou	4,807 08	
July 1, 1878, amount available		26,445 94
Amount (estimated) required for completion of existing project for raft-work		130,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880		50,000 00

L 4.

IMPROVEMENT OF CYPRESS BAYOU, TEXAS.

Operations upon this work have heretofore been confined to the improving of Cypress Bayou proper by dredging and straightening the channel by means of several cut-offs and by removing obstructions from the channel. The dredge-boat with which the work was done in former seasons sunk in the bayou the previous winter, so that no work was carried on upon the improving of the channel during the past fiscal year.

The appropriation was used in raising the old and building a new dredge. This work was carried on at a point on the bayou about 5 miles below Jefferson, under the supervision, first, of Mr. Joseph Burney, and afterward of Mr. M. Lydon, and the dredge was successfully launched in October, 1877.

The workmanship reflects great credit upon the workmen engaged, for the manner in which it was conducted, especially under the circumstances, being in the woods and without the usual facilities of a shipyard, and during a heated term which caused a great deal of sickness among the men.

After the hull was placed in the water, the engine and boiler and other machinery were placed in position. The funds being nearly exhausted work was suspended in November, 1877, and the property left in charge of a watchman.

With the amount appropriated June 18, 1878, it is proposed to finish putting up the other machinery of the dredge and build a new cabin; the cost of this work will be about $3,000. The balance of the appropriation will be applied to the work of improvement. This will consist in widening the three channels already dug, and to dredge another channel from the bayou into the head of the lake, thus giving good navigation from Jefferson to the lakes below.

In my report of last year I estimated that it would take $20,000 to finish the dredging and straightening the channel. The new hull of the dredge cost more than I had originally thought it would, owing to the difficult condition in which we had to carry on work, and in addition the amount of the appropriation not being up to the estimate, a certain amount has always to be reserved for the care of property, &c. I deem it necessary also to carry out the dredging through Fairy Lake and make the connection through to Sodo Lake. For this work I estimate $20,000.

The former appropriations are as follows:

By act approved June 10, 1872	$10,000 00
By act approved March 3, 1873	50,000 00
By act approved August 14, 1876	13,000 00
By act approved June 18, 1878	15,000 00

For collection district and port of entry see report on removal of raft in Red River and closing Tone's Bayou, La.

COMMERCIAL STATISTICS.

The city of Jefferson stands at the head of navigation, and is the principal distributing point for Eastern Texas. The city contains about 5,000 inhabitants, a court-house, market-house, and two banks, having a paid-up capital of over $250,000.

When the bayou is open for navigation, which generally extends over

6 months, 2 steamboats per week arrive from New Orleans, and during the season 2 or 3 from Saint Louis.

The cotton receipts at Jefferson for the year ending August 31, 1877, was 45,000 bales. Of this, 31,000 were forwarded to market by steamboats, and 14,000 by railroad.

Amount of sales during 12 months:

Groceries and produce	$680,000 00
Dry goods	350,000 00
Hardware	120,000 00
Groceries and dry goods, mixed	760,000 00
Drugs, clothing, &c	260,000 00
Machinery, wagons, &c	250,000 00
Total	2,420,000 00

Money statement.

July 1, 1877, amount available	$9,900 73	
Amount appropriated by act approved June 18, 1878	15,000 00	
		$24,900 73
July 1, 1878, amount expended during fiscal year		9,854 32
July 1, 1878, amount available		15,046 41
Amount (estimated) required for completion of existing project		20,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		20,000 00

L 5.

REMOVING SNAGS AND OTHER OBSTRUCTIONS FROM RED RIVER, LOUISIANA.

No work has been done on the lower part of this river by the government with a view to make it such a navigable stream as the great commercial interests at stake would warrant. Above Shreveport the operations of removing the raft have tended toward keeping that section of the river in a good navigable condition; below Shreveport nothing whatever has been done in the way of improvement, and the river is full of snags, wrecks, and sunken logs, (the remains of the old raft), and the low-water channel is greatly endangered by overhanging trees.

Below I give a list of obstructions that will give some idea of the amount of work that will be required upon the river, and in addition the low-water navigation at many of the shoal places could be greatly improved by building single and comparatively inexpensive wing-dams.

By act approved June 18, 1878, the sum of $25,000 was appropriated for snagging purposes. This amount is sufficient for this season's work, but operations will have to be continuous for several years, and I estimate that it will take $175,000 (including cost of steamer) to effect the object in view.

I have made arrangements to send the snag-boat Wagner into the river for a short season and remove the most dangerous obstructions.

LIST OF OBSTRUCTIONS TO LOW-WATER NAVIGATION IN RED RIVER FROM SHREVEPORT, LOUISIANA, TO ITS MOUTH.

From Shreveport to Coushatta, a distance of 140 miles, there are 32 wrecks of steamboats, 21 of which are more or less in the way of navi-

gation. The banks show very many projecting logs, and there are also a large number of bad log-piles and snags in the river. There are many hanging trees and slides from the banks; in fact, nearly the whole distance has obstructions to low-water navigation and needs improvement.

From Coushatta to Campte, a distance of 40 miles, there are the wrecks of the Illinois Belle, Selma, Travis Wright, and Dixie; log-piles at Jones's, Brownsville, Shortway, and Dixie Reach, as well as snags and stumps at other points.

From Campte to Grand Ecore, a distance of 20 miles, there are the wrecks of steamers Gladiola and Glide; also a barge of machinery, all in the middle of the river at different points. There also some very bad snags, log-piles, and stumps.

From Grand Ecore to Upper Falls, a distance of 100 miles, there are the following obstructions: Stumps in Opossum Foot Reach; clay lump below Avoca plantation; logs above Ulster wood-yard; clay lump opposite Fairmount plantation; at Deloache's Rocks in middle of river; clay lump below Bismarck Landing; wreck, lump, stumps, and logs in Mirabeau Reach; snags and logs below and above Colfax; lumps near Eureka Landing; logs near Ovid Saint Andre's; stumps and logs below and above Durand's Landing; very bad log-piles below and above High Die Landing; snags and logs below Faveron's Landing; very bad logs and some snags at O. K. Bar, regarded as a bad place. At Prud L'homme's Lower and Upper Bends and vicinity navigation is extremely dangerous and difficult on account of the wrecks of steamers Glasgow and Monsoon being in the middle of the river; it is also very loggy and stumpy. Above and below Saint Maurice cut-off there are some very bad log piles and snags; logs and snags above Cammack's plantation. At Tucker's Reach there are several crossings, logs, snags, and wreck of steamer Homer. Navigation is more difficult here from being a shoal place in the river. There is also a very bad log pile opposite Butler's Landing.

Alexandria, Upper and Lower Falls.—The river is very shoal and current very rapid, with crooked channels. There are two steamboat shafts on the Upper Falls, which are very much in the way and have caused injury to several boats.

From Alexandria to mouth of Red River, 160 miles.—There are snags and logs near Negro Point, Barbin's Landing, Snaggy Point, Mrs. Ferguson's, Mrs. Vaughan's, Kanomie, and Grand Bend. There is also a raft, an obstruction dating from the recent civil war, which is very bad and dangerous, and there are other points in its immediate vicinity which could be greatly improved by the removal of stumps and logs. At Rapian's and Grand Point clay lumps have formed in the middle of the river by slides from the banks, and there are also many dangerous stumps in the way. This place needs attention very badly.

For commercial statistics see report for removing raft in Red River and closing Tone's Bayou, La.

Money statement.

Amount appropriated by act approved June 18, 1878	$25,000 00
July 1, 1878, amount available	25,000 00
Amount (estimated) required for completion of existing project	150,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880	75,000 00

L 6.

IMPROVEMENT OF THE MOUTH OF RED RIVER, LOUISIANA.

The work to be inaugurated for this improvement will have for its object the keeping open of a navigable channel between the Red River and the Mississippi, and between the latter and the Atchafalaya.

At the present time the condition of affairs is such that at low-water it is extremely difficult for steamers to enter or leave the mouth of the river. In fact, in December, 1876, a number of steamers, comprising three-fourths of those plying in Red River and its tributaries, were detained unable to make the passage. This gradual closing of the river has been going on ever since 1831, when Captain Shreve made his cut-off, and now the complete separation of Red River and its tributaries, and also the Atchafalaya from the Mississippi, is threatened. It is only a question of time when it will be an accomplished fact. At the present time at low-water the upper channel around Turnbull's Island is closed, and the only remaining connection is by way of Lower Old River, and in this latter channel the greatest obstruction is at a place called "The Gut." By reference to the map transmitted to the department with my letter of April 13, last, a better understanding of the condition of affairs at the mouth of the river can be had. The government has never made any survey of the locality, and the data obtained upon which I based the estimates heretofore submitted was from a personal examination made in August last, and from information and reports obtained from the board of State engineers of Louisiana.

At the time my examination was made, the soundings made in Lower Old River, in the vicinity of the Atchafalaya, show how great the difference is in the depth in so short a distance. At the same time the Atchafalaya itself is deepening very greatly, and as it enlarges, the bar opposite gradually extends, and threatens soon a condition of affairs such that at low-water the volume of Red River will be entirely absorbed. The "Gut" is near the place where the greatest difficulty is experienced at low-water. A reference to the sketch above referred to will show the depth of water through that passage on the 20th of August last. Now, on that day the gauge at Red River Landing read 12.05 above low-water. Had the river been at its lowest stage it is presumed "The Gut" would have been dry and a complete separation of the river would have occurred.

For a temporary measure of relief, the plan as pursued by the State engineers of Louisiana last year was, by the aid of a couple of tugs and a steamer lashed together, to stir up the mud, and thus cut a channel through "The Gut" wide enough for two boats to pass. As a temporary measure it succeeded very well, and will again be attempted should circumstances require.

The permanent plan as recommended is to build a dam across the channel between the head of the Atchafalaya and the head of Turnbull's Island, thus turning the water of Red River through the upper channel into the Mississippi, while at the same time a connection between the Mississippi and the Atchafalaya can be made through Lower Old River.

The estimate I presented for this work was $300,000, based upon my own examination and upon data obtained from the board of State engineers of Louisiana. Now that funds are available for the work, I propose immediately to have an examination of the entire locality made (as some changes have undoubtedly taken place), with a view of obtain-

ing all possible data, when a full plan with detailed estimates can be presented, and the method of carrying on the work, whether by hired labor or by contract, can then be fully determined upon. In the mean time, even before the work is fully inaugurated, it might be necessary, as a temporary means of relief, to resort to the dredging out of the channel, the same as heretofore carried out by the State engineers.

Money statement.

Amount appropriated by act approved June 18, 1878	$150,000 00
July 1, 1878, amount available	150,000 00
Amount (estimated) required for completion of existing project	150,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.	150,000 00

L 7.

IMPROVEMENT OF THE HARBOR AND OF MISSISSIPPI RIVER, AT MEMPHIS, TENNESSEE.

In January, 1877, I made a survey of the Mississippi River and harbor of Memphis, with a view of determining the best means to protect the wharf and landing from destruction from the erosion of the Mississippi River, and in February I presented my report, with plan and estimates, to effect the object in view; this plan being to protect the caving bank from about 10 feet above low water to the maximum depth with a covering of brush formed into proper shapes and loaded with stone. The average width of this covering will be about 175 feet, and the length of shore to be protected about 7,600 feet. This project having been approved, I propose to commence operations so soon as the stage of water will permit. Some few additional examinations will be made, as since the data of the survey, upon which the plan was based, some changes have taken place along the entire front of the city. Brush can be obtained in quantities in the immediate vicinity and stone can be had from North Alabama. The total estimated cost of this improvement was $170,000, of which amount $46,000 was appropriated by act approved June 18, 1878, and with this it is proposed to commence at the mouth of Wolf River, and work down stream, as this portion of the front is the part really needing the first protection, and work will be continuous to the extent of the funds available.

If future appropriations be made, the whole city front will be protected in like manner.

Money statement.

Amount appropriated by act approved June 18, 1878	$46,000 00
July 1, 1878, amount available	46,000 00
Amount (estimated) required for completion of existing project	124,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.	124,000 00

L 8.

IMPROVEMENT OF THE HARBOR AND MISSISSIPPI RIVER AT VICKSBURG, MISSISSIPPI.

The Board of Engineers constituted by Special Order No. 141, A. G. O., Washington, D. C., June 28, 1877, took under consideration the sub-

ject of the preservation of the harbor of Vicksburg, and rendered a report upon the same with plan and estimates for the work. This report will be found in Senate Ex. Doc. No 55, Forty-fifth Congress.

The Board recommended that work for the protection of the harbor should be carried on in the following order:

1. Protection of the Delta Point, estimated cost	$84,000 00
2. Construction of bar dike, estimated cost	90,100 00
3. Dredging inner harbor, estimated cost	80,000 00
Total estimated cost	254,100 00

In accordance therewith it is proposed to carry on the work in the above order; the idea being, in the protection of the Delta Point, to hold the deep water where it is now, as the continued caving of the point carries the whole river down stream and farther from the city landing.

The plan of protection is to cover the shore above the Delta Point with brush mattresses loaded with stone, this covering to extend from low-water mark out 150 feet along the bottom.

Before proceeding with the work it is proposed to make an examination of the harbor to determine what changes, if any, have taken place since the survey upon which the Board based their plan and estimates.

Money statement.

Amount appropriated by act approved June 18, 1878	$84,000 00
July 1, 1878, amount available	84,000 00
Amount (estimated) required for completion of existing project	170,100 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.	90,000 00

REPORT OF BOARD OF ENGINEERS.

SAINT LOUIS, MO., *January* 22, 1878.

GENERAL: The Board of Engineers constituted by paragraph 6, Special Orders No. 141, from Headquarters of the Army, Adjutant-General's Office, dated Washington, D. C., June 28, 1877, to examine and report upon the most advisable means of preserving the water-front of Vicksburg, and of arresting the danger which appears to be apprehended from the cut-off opposite that city, having been reconvened by its president, met in Saint Louis on January 14, 1878.

In the report of the Board, dated July 20, 1877, it was stated that the facts then in their possession were not sufficiently comprehensive to enable them to submit either a definite plan or estimate for accomplishing the object proposed for their consideration. In view of this fact, a committee of citizens of the city of Vicksburg undertook to have such surveys made as the Board deemed necessary for a full understanding of the subject. These surveys are made during the course of the past season, and the results obtained with the necessary maps and profiles have been placed at the disposal of the Board. We are therefore enabled to submit a final report upon the subject.

A preliminary report of the Board sets forth the condition of affairs at Vicksburg at the date of their visit. Since that time the recession of the Delta Point has been steadily progressing as well as the caving of the Mississippi bank below Vicksburg. The erosion at the point has been at the rate of 300 feet a month during the flood stages, and will probably average over 100 feet per month throughout the year. The dry bar below the point moves down with it, and has already extended past the landing at Delta.

The filling up of the harbor of Vicksburg has progressed rapidly, and

although the extreme stage of low water was not reached, the soundings taken about the middle of August, 1877, showed that at low water the bottom of the river would be dry as far up as Crawford street, between the elevator and wharf-boat. This filling in has been going on ever since, so that the situation of affairs is really much worse than is shown by the maps. It appears from the soundings and from float observations, that a considerable quantity of water thrown off from the main body of the stream follows approximately the direction of the shore-line above the Delta Point, and striking the Vicksburg shore obliquely is deflected upstream as an eddy current, having along the city front a velocity of about a mile an hour. The water thus entering the lower end of the harbor flows around De Soto Island and out at the upper end of the lake. The action of this eddy current has been to cause an immense deposit of mud in the harbor itself, and also on the line of an ideal prolongation of De Soto Island toward Ryan's saw-mill. The west end of the old bed has not been appreciably silted up, all the deposits having apparently taken place in the portion nearest Vicksburg.

It appears from these facts that if at the time of the cut-off the Delta Point had been held, this mud-carrying current would have passed up to the west of De Soto Island, and that channel would have been silted up and closed, as is usually the case with these cut-off lakes.

The harbor in that case would probably have remained an open lake, having a narrow passage to the river at its lower end; but this passage could probably have been enlarged and kept open by a moderate amount of dredging annually. As the case actually stood, however, the Delta Point was unprotected, and receded rapidly under the action of the current, so that the water thrown off from the main body in the direction of the old channel, instead of being deflected by the island into the west arm of the lake, was allowed to strike the Vicksburg shore and to be by that means directed into the east arm of the lake or harbor proper.

Even if the Delta Point were held, this depositing action would continue until the bar reached the surface of the water and formed a new shore-line. After this was the case the upper or west arm of the lake would receive the deposit and would soon fill up. The continued caving of the Delta Point carries the whole river downstream, and farther from the city landing, and should be at once checked, no matter what the subsequent plan of improvement may be, for a continuance of this action will greatly increase the ultimate cost of any plan of clearing the entrance to the harbor.

The Board are of the opinion that this protection should cover about 7,000 feet of the shore above the Delta Point. The plan they propose contemplates a double row of brush mattresses each 75 feet wide by 100 feet in length, which shall be sunk against the bank and form a continuous revetment, extending from low-water mark 150 feet out along the bottom. These mattresses should be two feet in thickness and be held in place by a light covering of stone or other heavy material.

The next thing to be done will be to cut off the eddy current from the harbor, and this can only be done by the construction of works which will form an artificial prolongation of De Soto Island. A dike built on the line shown on the map would answer this purpose if carried up to high-water mark, but would necessarily be very costly. It would be possible to build it in installments, allowing the bar to fill up around it and then raising the crest until the desired height was attained. But either method would be expensive and would require a massiveness of construction altogether out of proportion to the resistance it is expected to overcome. The object desired is to obstruct this current so as to induce a rapid deposit on the outer slope and crest of the bar.

This end would be accomplished by the means already referred to, but it is desirable that less expensive ones should be used if possible.

For this reason the Board recommend the employment of a method which has been successfully used in India, and also on the Missouri River at Nebraska City. Long, loose bundles of brush are made, which, when completed, are forty or fifty feet long and five or six feet in diameter. They are constructed by firmly lashing the butts of the brush to a small rope, which serves as a core, and when completed they are anchored along any line selected, so as to float approximately upright in the water. The free end is to be buoyed up by empty barrels, and bags or barrels filled with clay or stone will serve as anchors. The action of a sufficient number of these brush ropes is to check the current and induce a rapid deposit. By making the ropes sufficiently long they can be made to reach to the surface of the water, even when in flood, and will thus at once cut off the eddy current which carries the mud into the harbor. The Board are disposed to think that by the use of this simple and inexpensive device the bar may be raised to such height that a dike of comparatively small dimensions will suffice for the protection of the harbor.

When the eddy current is cut off from the east arm, it will probably flow in at the other end of the lake, which will rapidly silt up, and this action, while in many ways beneficial, will not be at all injurious to the harbor of Vicksburg. There will then still remain the task of clearing away the mud from the front of the landing, and this, although extensive in amount, can still, owing to the softness of the material, be dredged out at comparatively little cost. After the Delta Point has been protected, and the bar-dike raised to high-water mark, it is probable that a small annual outlay will be required to keep the mouth of the harbor open.

The attention of the Board was urgently called to the plan advocated of opening communication between the Yazoo River and the head of the lake, so as to cause the Yazoo to flow past Vicksburg and keep the harbor open. At the request of the Board, the surveys executed by the city were extended so as to embrace the various lines communicating with the Yazoo, and we have formed estimates of the cost of carrying it out by three different routes. The discharge of the Yazoo at low water is too small to remove the immense accumulation of mud already in place, but it might obviate the necessity for annual dredging if the works already described were once completed. To carry out the idea, it would be necessary to dam the Yazoo below the new channel, and also to carry a dam across the west arm of the lake, so as to force the Yazoo to flow past Vicksburg.

This latter operation would be very expensive under the present condition of affairs, but the cost would be much lessened, if not done away with entirely, if the other works recommended were first constructed and the west arm of the lake allowed to silt up.

The first route examined runs through Chickasaw Bayou and McNutt's Lake; the second through Boat Slough, Indian Camp, and Flat Lakes; the third through the dead end of Old River, Long Lake, and Cat-Tail Bayou. The last mentioned is the shortest and most desirable route both as regards expense and damage to property.

The Board are of the opinion that the works here considered should be taken up in the following order:

1. Protection of Delta Point.
2. Construction of bar-dike.
3. Dredging out of inner harbor.
4. Diversion into the lake of the Yazoo River.

ESTIMATES.

Revetment of Delta Point.

Protection of 7,000 feet of shore-line, by mattress revetment, 150 feet wide and 2 feet thick, at $12 per linear foot of bank		$84,000

Construction of dike and dredging.

First estimate:

Cross-dike, 40 feet high and 2,100 feet long, composed of brush and stone and held by piles	$42,000	
Longitudinal dike, 40 feet high, 3,000 feet long, built as above, but wider	112,000	
Total cost of dike raised to average high-water mark		154,000
Dredging		100,000
		254,000

Second estimate:

Dike built in installments, 20 feet first season, and raised 10 feet in each of two succeeding seasons:		
First season, 20 feet high	$73,000	
Second season, raised 10 feet	20,000	
Third season, raised 10 feet	20,000	
		113,100
Dredging		100,000
		213,100

Third estimate:

Surface of bar raised by system of brush ropes, and dike 20 feet high built on top:		
Cost of brush ropes	$17,000	
Dike 20 feet high	73,100	
		90,100
Dredging		80,000
		170,100

Diverting the Yazoo River.

Chickasaw Bayou route:

Dam across Yazoo River below mouth of Chickasaw Bayou	$88,000	
Excavation, 12,500,000 cubic yards, at 20 cents	2,500,000	
Dam across Lake Centennial	180,000	
		2,768,000

Boat Slough route:

Dam across Yazoo River	88,000	
Excavation, 11,350,000 cubic yards, at 20 cents	2,270,000	
Dam across Lake Centennial	180,000	
		2,538,000

Long Lake route:

Dam across Old River	300,000	
Excavation, 6,500,000 cubic yards, at 20 cents	1,300,000	
Dam across Lake Centennial	180,000	
		1,780,000

Recapitulation.

Revetment of Delta Point	$84,000
Construction of dike, third estimate	90,100
Dredging	80,000
Total	254,100
Division of Yazoo River by Long Lake route	1,830,000

The following appendixes are attached to this report:

A. Copy of order convening the board.
B. Preliminary report of July 20, 1877.
C. Copy of a letter addressed by the board to the chairman of the citizens' committee of the city of Vicksburg.
D. Copy of order reconvening the board.
E. Report made to the board by Mr. T. G. Dabney, C. E., on the surveys executed by him for the citizens' committee of the city of Vicksburg.
F. Map showing harbor of Vicksburg and Yazoo River, with proposed routes of communication. Reduced from the copy furnished by the citizens' committee of the city of Vicksburg. Scale 1 inch to 2,000 feet.
G. Map showing harbor of Vicksburg and works proposed by the board. Reduced from the copy furnished by the citizens' committee of the city of Vicksburg. Scale 1 inch to 1,000 feet.

All of which is respectfully submitted, by your obedient servants,

J. H. SIMPSON,
Colonel Engineers and Brevet Brigadier-General, President of Board.
CHAS. R. SUTER,
Major of Engineers.
W. H. H. BENYAURD,
Captain of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

A.

ORDER CONVENING THE BOARD.

[Special Orders No. 141.]

HEADQUARTERS OF THE ARMY,
ADJUTANT-GENERAL'S OFFICE,
Washington, June 28, 1877.

[Extract.]

* * * * * * * *

6. By direction of the Secretary of War, a board of engineers, to consist of Col. J. H. Simpson, Maj. C. R. Suter, and Capt. W. H. H. Benyaurd, will assemble at Vicksburg, Miss., on the 17th day of July, 1877, or as soon thereafter as practicable, to examine and report upon the most advisable means of preserving the water-front of Vicksburg, and of arresting the danger which appears to be apprehended from the cut-off opposite that city.

The board will also submit such estimates as may be thought advisable to present to the early consideration of Congress.

The junior member will act as recorder.

* * * * * * * *

By command of General Sherman.

THOMAS M. VINCENT,
Assistant Adjutant-General.

Official:
L. H. PELOUZE,
Assistant Adjutant-General.

B.

PRELIMINARY REPORT OF THE BOARD.

VICKSBURG, MISS., *July* 20, 1877.

GENERAL: The board of engineers constituted by paragraph 6, Special Orders No. 141, from headquarters of the Army, Adjutant-General's Office, Washington, June 28, 1877, to examine and report upon the most advisable means of preserving the water-front of Vicksburg, and of arresting the danger which appears to be apprehended from the cut-off opposite that city, have the honor to report that in accordance with the above orders they met at Vicksburg on the 17th instant, and proceeded to investigate the subject committed to their charge.

rapid deterioration and threatened destruction of their harbor since the forma- 1876 of the cut-off below the town, has been a matter of much concern to the s of Vicksburg. They have had a survey executed of the harbor and peninsula te, and propose to make other surveys which are needed for a full understand- the subject.

fly stated, the situation is as follows:

break through the old peninsula is now about 6,000 feet wide, the upper edge opposite a point in Vicksburg, midway between the marine hospital and the ss House. The cut is rapidly widening, the Louisiana point receding toward

The *debris* washed away is swept around the point, and forms a large bar, dry sent stage of water (35 feet by gauge), and extending down past the wharf-boat ta. The low ground below Vicksburg, receiving the direct impact of the tre- us current, is going in very rapidly. The water-slope is over 6 inches to the nd soundings made in our presence along this shore failed to find bottom with a) feet in length. In the line of the cut-off a great bar is forming, which will proba- dry at low-water, and will extend from the farther Mississippi shore across the f the lake nearly to the Vicksburg wharf. This bar, lying directly in the line of ater deposits, is sure to grow very rapidly, and to be composed of hard materi- Above the point where the current strikes the Vicksburg shore a strong eddy sets am along the wharf-front. This eddy carries up vast quantities of mud, and ens soon to fill up the lower end of the harbor.

ording to some soundings made by citizens interested in the matter, this fill, the past month, amounts to 8 or 10 feet, and the present depth opposite the boat indicates that even without further increments the bottom will be bare at ater. Our information is not sufficiently extensive to enable us to say definitely r down this will extend; but it seems probable that during the coming low- access to the wharf-boat, elevator, and in fact to the whole water-front will be f. The recession of the Delta Point, about 600 feet a month, will, of course, this mud-bar downstream at a corresponding rate.

re is no telling where this recession will cease, but it is probable that it will con- nearly, if not quite, down to Delta, about a mile below its present location. The of the bank at King's Point above the cut-off and of the shore below Vicks- re favorable for restoring the equilibrium, but unless prevented the erosion will ly go on to the extent indicated at least. It may, therefore, be necessary to is point; it certainly appears so at present, but we cannot decide definitely on bject until we know what changes may take place at low water.

all-important point of keeping open the harbor of Vicksburg has been consid- y us as well as the meager information at our command would allow; but at t we can only state the necessity of maintaining a dredged channel seems inevi-

A proposition advanced meets much favor here, viz, to turn the Yazoo River Chickasaw Bayou, and bring it into the lake near the national cemetery, with a o keeping the harbor open. Careful surveys and measurements will be needed de this point, and until we have these data we cannot give a decided opinion. can be done without injury to the navigation of the Yazoo, the influx of that , if properly controlled, might at least prevent the entrance of the mud-deposit- dy current from the Mississippi, and to that extent maintain an open harbor; do not believe that it would supersede the necessity of dredging at its conflu- ith the Mississippi.

citizens of Vicksburg propose to make the required examinations and to furnish the results. We have therefore concluded to adjourn until we are put in pos- of this information, when a full report, with estimates, will be forwarded to r the consideration of Congress.

f which is respectfully submitted.

J. H. SIMPSON,
Colonel Engineers, Brevet Brigadier-General U. S. A., President of Board.
CHAS. R. SUTER,
Major of Engineers.
W. H. H. BENYAURD,
Captain of Engineers.

Gen. A. A. HUMPHREYS,
Chief of Engineers U. S. A.

C.

ADDRESSED BY THE BOARD TO THE CHAIRMAN OF THE CITIZENS' COMMITTEE OF THE CITY OF VICKSBURG.

VICKSBURG, MISS., *July* 20, 1877.

R SIR: The Board of Engineers directed by the Secretary of War to examine and upon the most advisable means of preserving the water-front of Vicksburg, ap-

preciating the great importance of the question to the city, and desiring to arrive some proper solution at as early a day as practicable for the consideration of Congr wish to state that at the present time they have not sufficient data at their comma for so full and complete an investigation as a subject of so much importance deman

As no funds were furnished the Board with which to make the necessary surveys a examinations, it is respectfully requested, if within the power of your committee, t the surveys already commenced by you be continued so as to embrace all the poi enumerated below, and the information be furnished at the earliest date practical The Board will then be in a condition to consider the subject in all its bearings, w the hope that some plan may be devised for the protection of the water-front of y city.

There will be required a survey of inner harbor from national cemetery to po where bank begins caving, showing cross-sections of water-way, the distances ap increasing toward the upper end, say four sections below Glass Bayou and two abo one section from old point of peninsula to bight of bend; two sections on upper s of island at end nearest the Mississippi. Each cross-section should have at least thi well-distributed soundings.

Shore-line of Louisiana Point and low ground below Vicksburg at low-water.

Outlines of principal bars at present stage and at low-water.

Longitudinal profile at present stage and at low-water of water-surface along L isiana Point, from one mile above the point at Delta, following the channel-line, w located soundings on same line.

Cross-sections of the Mississippi River at present stage and at low-water, say section back of Delta; one from point to opposite side of Cut-off; one from poin Vicksburg shore running across the bar; and one more half-way down to Delta.

Current-observations with floats to show direction and velocity of currents into through the inner harbor, both at present stage and at low-water.

Survey from head of lake to Yazoo River along Chickasaw Bayou, &c., and up Yazoo to Snyder's Bluff. This should be made at low-water.

Careful profile along whole route, with profile of Yazoo River from head of sur to head of proposed cut.

Cross-section and measured discharge of Yazoo River at low-water.

Cross-section of Yazoo at site of proposed dam.

Sections along the bayou and route to show amount of cut required.

Very respectfully, your obedient servant,

J. H. SIMPSON,
Colonel of Engineers, President of the Boar

To Mr. J. F. BAUM,
Chairman Citizens' Committee.

D.

ORDER RECONVENING THE BOARD.

ENGINEER'S OFFICE, UNITED STATES ARMY,
Saint Louis, Mo., January 10, 187

The board of engineers constituted by Special Orders No. 141, Headquarters of Army, Adjutant-General's Office, dated June 28, 1877, will reassemble at Saint Lo Mo., on the 14th day of January, 1878, "to examine and report upon the most ad able means of preserving the water-front of Vicksburg and of arresting the dan which appears to be apprehended from the cut-off opposite that city."

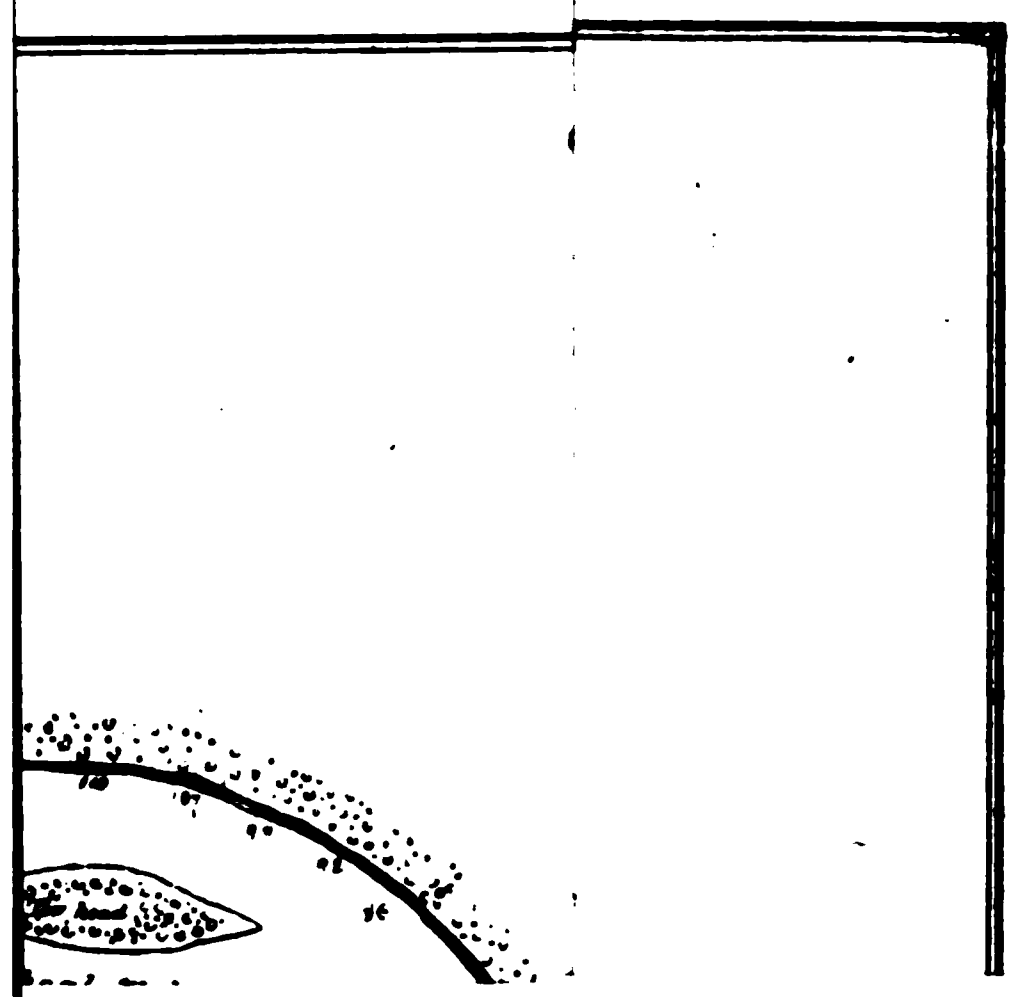
J. H. SIMPSON,
Colonel of Engineers, President of the Board

E.

REPORT OF MR. T. G. DABNEY, CIVIL ENGINEER.

VICKSBURG, MISS., *January* 10, 187

GENTLEMEN: In compliance with the request contained in your letter of July 20 la to the citizens' committee of the city of Vicksburg, that additional surveys and aminations be made for the purpose of affording information which would enable y to determine upon some practicable plan, if possible, for the preservation of Vicksbur water-front, I have the honor to report that, having been authorized and employed the city authorities to execute the work required to be done, I proceeded at once to so, and having made the examinations specifically indicated in your letter above ferred to, I extended my operations further, with your approval, so as to comprehe more ground and cover a wider field of inquiry.



KSBURG

The most prominent feature in the work required appeared to be the examination of the Yazoo River, to ascertain its volume of discharge at low-water, the profile of its surface along the lower reaches, and to examine the channels of Chickasaw Bayou and McNutt's Lake, with a view to determining if it were feasible and expedient to divert the Yazoo River from its present course through those channels into the newly-formed lake at Vicksburg, so as to cause its waters to flow through the harbor and by the landing of the town, and also to ascertain the cost of such work.

I therefore made a careful examination with this object, and then examined a number of other possible routes through which the Yazoo might be made to pass, to wit: One embracing Thompson's Lake; another embracing Boat Slough, Indian Camp, and Flat Lakes; another through the "Dead End" of Old River, Long Lake, and Cat-Tail Bayou; and a fourth through Barnett's Lake and Willow Bayou.

These lakes and channels were all carefully sounded, and cross-sections made where it was deemed desirable to have them. There were also lines of levels taken along all the various lines of survey connecting the Yazoo River with the lake at Vicksburg and the interlying lakes and channels.

A traverse line was carried along the bank of the Yazoo from Snyder's Bluff to its mouth, and along Old River to the Mississippi, and thence along the left bank of the latter to King's Point, where it connected with the system of triangulation previously made, which covered the lake and river in the vicinity of Vicksburg and Delta. All of the other convergent lines of survey from the Yazoo also connected with the harbor system. The traverse along Yazoo and Old Rivers was made to take in both banks by deflections on flags set on the opposite sides. The profile of the Yazoo was also carried down to its mouth and through Old River to the Mississippi, and down the latter to the landing at Delta.

At a point on the right bank of Old River, about four miles above its entrance into the Mississippi, the latter had, by caving away the east bank in the bend outside of Pawpaw Island, approached to a distance of only 275 feet from the other. The difference in the elevation of the water was found to be 1.10 feet in favor of the Mississippi. This difference, at a much higher stage of water, was nearly double the above figure, being 2.05 feet. The respective stages were 15 and 42 feet above low water. It had been suggested that a part of the water from the Mississippi might be made available by an excavation through this narrow neck. I therefore ran a line from this point across the peninsula formed by the two ends of Old River to a point opposite the western end of Long Lake.

It is proper to observe, however, that the Mississippi has almost forsaken the bend on this side of Pawpaw Island for the shorter route west of it—one of the consequences of the Vicksburg Cut-off—and this bend is shoaling up.

The difference in elevation of the surface of water in the Yazoo and that in the lake at Vicksburg varied very little on the several lines examined, as the fall in the Yazoo was very slight with the then prevailing relative stage in the Mississippi. The maximum difference was found to be 1.67 feet, which is not sufficiently great, in my opinion, to endanger the navigation of that stream, if it should be turned along any of those lines into the Vicksburg Harbor.

The profile of the Yazoo, as determined by my observations, has, I think, but little significance, since it is so easily influenced by the relative stage in the Mississippi that a rise or fall in the latter would effect important modifications in the former.

Upon gauging the flow of the Yazoo at two different stages, to wit, 6 and 10 feet above low-water, the discharge was found to be respectively 3,667 and 3,371 cubic feet per second.

An elaborate system of soundings was made, covering the harbor and lake at Vicksburg and the Mississippi River from King's Point above to the Delta Landing below. There was found to be a reversed current running through the harbor and lake, entering at the lower end, passing along in front of the town, rounding the northern end of the island, and thence passing into the river again through the upper end of the lake.

This current from Ryan's Mill to the Cotton Compress, a distance of 2,300 feet, has a velocity (mean) of 1.81 feet per second, and from the compress to the mouth of Glass's Bayou, 4,600 feet, the mean velocity is 1.10 feet per second; the stage of water being 17 feet above low water. The velocity is greater for a higher stage and less for a lower.

After passing Glass's Bayou the velocity diminishes, until, having reached the large volume of water at the northern end of the island, its further progress can scarcely be perceived, but becomes more marked with the reduced section as it approaches the southern end of the island on the upper side and passes out into the main current of the river.

Subsequent observations here, with the water 24 feet above low water, showed a velocity of 0.54 foot per second from a point 5,000 feet above the lower end of the island until it came within the influence of the main current.

This stream of water conveys a large quantity of mud and sand, held in suspension, into the harbor, nearly the whole of which is precipitated in front of the landing. This

result is decidedly shown by the soundings taken and by the different color of the water after reaching the upper end of the island.

There is a large area of the harbor upon which, at the date of the soundings taken, from the 13th to the 20th of August last, the bottom had been raised to the level of the low-water plane, and a portion considerably above, indicating a deposit of about 50 feet in depth since the cut-off, which occurred April 27, 1876. This area occupies that portion of the harbor immediately in front of the landing, and extends entirely across to the island.

The point of the Delta Peninsula was found to have receded by caving 975 feet from the middle of March to the middle of August last. This period covered a little more than one-half of the rapidly-caving stage of the river, so that the average rate per month for the whole year may be taken at about 125 feet.

In view of the enormous deposit going on in the harbor, together with the rapid recession of the main channel in consequence of the caving of Delta Point, it is not difficult to conjecture what will be the fate of Vicksburg's commerce at a time in the near future if these baleful agencies are not speedily arrested. And I will here take the liberty to urge especially the importance of prompt measures to check the further encroachment of the river upon Delta Point, the effect of its continuance being to greatly increase the difficulties to be encountered.

I submit herewith a map showing accurately the positions of Vicksburg and delta, with the harbor and river adjacent; the Yazoo, Old River, and the Mississippi from Snyder's Bluff to delta, and all the lakes, bayous, old channels, and other features contiguous to the lines of survey. Also, the soundings taken in the Mississippi River and harbor, Old River, and the various lakes examined, with profiles of the different lines of survey, and cross-sections of Yazoo River, Chickasaw Bayou, McNutt's Lake, and other channels.

I hope all the information has been afforded that you may find necessary to enable you to reach a solution of this problem, which is of so great importance to the commercial and other interests of the city of Vicksburg.

It may not be improper to remark that the destruction of Vicksburg's harbor closes access by water to the national cemetery, a work which has required a large expenditure of money, and which has been brought to such perfection of symmetry and beauty that it should be a matter of national pride to preserve to it the position originally designed in the selection of its location, overlooking the great national highway of commerce, which washes its outer wall with the waters collected from three-fourths of the Union, possibly bearing mementoes from every homestead of the poor fellows who lie there in eternal sleep where they fell in the service of their country.

I am indebted to my assistant, Mr. Horace M. Marshall, civil engineer, for careful and accurate levels taken by him and for other important service rendered.

Respectfully submitted.

T. G. DABNEY,
Civil Engineer.

General J. H. SIMPSON,
President of Board of United States Engineers.

L 9.

WATER-GAUGES ON THE MISSISSIPPI RIVER AND ITS PRINCIPAL TRIBUTARIES.

As there was no appropriation for last year, the observations of the rise and fall of the river were continued at nearly all of the gauges until the funds were exhausted, which was in October. Many of the observers, however, continued taking the readings, and sent them to this office without compensation, whereby we were enabled to keep a continuous record of the stage of water on all of the rivers.

No repairs could be made to the gauges, many of which, especially those on the Lower Mississippi, are in bad condition, and temporary means had to be resorted to to keep up the readings.

The gauges needing repairs are those at Carrollton, Florence, Helena, Jacksonport, Lake Providence, mouth of White River, Natchez, and Red River Landing. All the others are in good condition.

During the coming season a thorough inspection will be made of all

the gauges, and such as need it will be repaired. The observations will be continued at all the stations.

The observers are the same as those mentioned in previous reports, except here at Memphis, where the records were kept by this office.

Hydrographs of all the gauges were finished, and we now have a complete set from the date of establishment to the present time.

Copies of the gauge-records for the year ending June 30, 1878, are transmitted herewith.

Money statement.

July 1, 1877, amount available	$1,668 24	
Amount appropriated by act approved June 18, 1878	5,000 00	
		$6,668 24
July 1, 1878, amount expended during fiscal year		1,668 24
July 1, 1878, amount avilable		5,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		5,000 00

APPENDIX M.

ANNUAL REPORT OF MAJOR CHARLES R. SUTER, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1878.

UNITED STATES ENGINEER OFFICE,
Saint Louis, Mo., July 31, 1878.

GENERAL: I have the honor to submit herewith my annual report upon the operations committed to my charge during the fiscal year ending June 30, 1878.

I am, general, very respectfully, your obedient servant,

CHAS. R. SUTER,
Major of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

M 1.

REMOVING SNAGS AND WRECKS FROM THE MISSISSIPPI, MISSOURI, AND ARKANSAS RIVERS.

In my last annual report it was stated that the small balance remaining of the appropriation made by act approved August 14, 1876, and allotted to this work, would be held for the care of the boats and other property belonging to the work until such time as Congress should make a new appropriation for carrying it on. Subsequently, however, it was decided by the department that it would be expedient to devote a month's snagging operations to the Missouri River, and in accordance with your instructions the snag-boat Macomb was detailed to perform this duty. The whole fleet was then laid up in ordinary until Congress passed a special appropriation for this service of $40,000 (act approved February 7, 1878). As soon as two boats could be fitted for the field, the *Macomb* was sent to the Missouri River, and the *De Russy* to the Mississippi. Subsequently the *Macomb* was transferred to the Arkansas, and both boats were kept at work as long as the funds available would allow.

MISSISSIPPI RIVER.

Work on this stream was carried on by the snag-boats De Russy and Macomb, and extended from the mouth of the Missouri to Vicksburg, 846 miles. Three and a half months were devoted to these operations.

The snag-boat De Russy left Mound City, Ill., March 10, 1878, and began work at Cairo, proceeding downstream. On the 23d of March, she reached Memphis, and worked upstream again to Cairo, reaching that point April 3. She then started down the river, reaching Vicksburg, Miss., on the 28th of April. She then worked up the river, reaching Mound City, Ill., on the 27th of May, and was at once laid up.

The snag-boat Macomb, after leaving Missouri River on the 30th of October, 1877, cleared the Mississippi of snags as far down as Cairo. Time occupied, 9 days. On leaving Mound City for the Missouri, March 11, 1878, 9 days were devotedby the *Macomb* to clearing the channel between Cairo and the mouth of the Missouri River, and subsequently, in April and May, 13 days were devoted to snagging between Saint Louis and Memphis.

Table of work done in the Mississippi River.

Name of boat.	Number of snags pulled.	Weight in tons of 2,000 pounds.	Number of trees cut.	Drift-piles removed.	Number miles run.
R. E. De Russy	742	17,071.7	3,104	1	1,790
J. N. Macomb	147	2,123.6	242	.....	843
Total	889	19,195.3	3,346	1	2,633

MISSOURI RIVER.

The snag-boat Macomb was assigned to this river, and one and one-half months' work accomplished, the operations extending from the mouth to Lexington, 317 miles.

The *Macomb* left Mound City October 10, 1877, entered the Missouri River October 15, and on the 26th turned back from Sandy Hook, 165 miles from the mouth. She left Missouri River on the 30th of October, and was laid up at Mound City November 8, 1877.

The *Macomb* again left Mound City March 11, 1878, entered the Missouri March 20, and worked up to Lexington, 317 miles from the mouth. She turned back from this point on the 13th of April, and left the Missouri April 19, on her way to Arkansas River.

Table of work done in the Missouri River.

Name of boat.	No. of snags pulled.	Weight in tons of 2,000 pounds.	Drift-piles removed.	No. of miles run.
J. N. Macomb	393	3,361.3	13	1,329½

ARKANSAS RIVER.

The snag-boat Macomb was assigned to this river. Her operations extended from the mouth to Little Rock, 280 miles, and covered a period of two months.

The boat entered Arkansas River May 3, 1878, and had worked up to Little Rock May 12. She then worked down to Knott's Landing, and on the 20th again started up stream, reaching Little Rock on the 24th of May. She then worked down to Pine Bluff, and returned to Little Rock June 13. She then started to work down the river, and entered the Mississippi June 26. June 30 she was at Wiggins Landing, 26 miles below Cairo, *en route* to Mound City, Ill., to be laid up.

Table of work done in the Arkansas River.

Name of boat.	No. of snags pulled.	Weight in tons of 2,000 pounds.	No. of trees cut.	Drift-piles removed.	No. of miles run.
J. N. Macomb	430	5,346.3	1,177	11	1,337

Recapitulation of work during the fiscal year ending June 30, 1878.

Name of river.	No. of snags pulled.	Weight in tons of 2,000 pounds.	No. of trees cut.	Drift-piles removed.	No. of miles run.
Mississippi River	889	19,195.3	3,346	1	2,633
Missouri River	393	3,361.3	.....	12	1,328½
Arkansas River	430	5,346.3	1,177	11	1,527
Total	1,712	27,902.9	4,523	24	5,488½

OPERATIONS FOR THE COMING SEASON.

The liberal scale upon which appropriations were made this year will enable us to set about the much-needed work of renewing our working-fleet. Two boats will be taken in hand at once, and it is hoped that with some assistance from next year's appropriation we will have them ready for the field by June 30, 1879. Meanwhile the only two boats which remain available will be kept at work for so much of the season as may be necessary, the plan approved by you contemplating the following allotment of work:

Mississippi River	11 months.
Arkansas River	3 months.
Missouri River	8 months.

To bring our fleet up to full efficiency it will be necessary to provide for renewing one more boat and for repairing another and fitting her up for the removal of wrecks.

The work is situated in the collection-district of New Orleans. The amount of revenue collected at the port of Saint Louis, Mo., during the fiscal year ending June 30, 1878, was $1,552,723.93.

The commerce benefited by the work is that of the entire Mississippi Valley.

ESTIMATE OF AMOUNT REQUIRED FOR FISCAL YEAR ENDING JUNE 30, 1880.

For building one small iron-hulled snag-boat to carry machinery of one of the present wooden boats	$105,000 00
For repairing one wooden snag-boat and fitting it up for wrecking purposes	50,000 00
For completion of the two iron snag-boats now authorized	30,000 00
For working expenses of 5 boats, 10 months, each at $4,000 per month	200,000 00
Total	385,000 00

Money statement.

July 1, 1877, amount available	$9,174 79	
Amount appropriated by act approved February 7, 1878	40,000 00	
Amount appropriated by act approved June 18, 1878, viz:		
For Mississippi and Arkansas Rivers	$170,000 00	
For Missouri River	70,000 00	
	240,000 00	
		$289,174 79
July 1, 1878, amount expended during fiscal year		39,037 44
July 1, 1878, amount available		250,137 35
Amount that can be profitably expended in fiscal year ending June 30, 1880, viz:		
For Mississippi and Arkansas Rivers	$260,000 00	
For Missouri River	125,000 00	
		385,000 00

M 2.

IMPROVEMENT OF MISSOURI RIVER AT OR NEAR FORT LEAVENWORTH, KANSAS.

A report upon this subject was submitted to you on the 24th of May, 1878. No survey had been made, however, and one will be undertaken as soon as possible. When it is completed a plan for the expenditure of the present appropriation, with estimates for continuing the work, will be submitted to you.

The work is situated in the collection-district of New Orleans, and the nearest port of delivery is Omaha, Nebr.

Amount of revenue collected at Omaha, Nebr., during fiscal year ending June 30, 1878, was $2,364.44.

Money statement.

Amount appropriated by act approved June 18, 1878	$25,000 00
July 1, 1878 amount available	25,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880	35,000 00

M 3.

IMPROVEMENT OF MISSOURI RIVER AT ATCHISON, KANSAS.

A survey of this locality was made and a report, with plan and estimate, was submitted to you on the 3d January, 1878. (Printed in Senate Ex. Doc. No. 30, Forty-fifth Congress, second session.)

The extraordinary flood now prevailing along the river will render a resurvey necessary to determine how the appropriation for the present year can be most judiciously expended. As soon as possible a definite plan, with estimates for continuing the work, will be submitted to you.

The work is situated in the collection-district of New Orleans, and the nearest port of delivery is Omaha, Nebr. The nearest fort is at Leavenworth, Kans.

Amount of revenue collected at Omaha, Nebr., during the fiscal year ending June 30, 1878, was $2,364.44.

Money statement.

Amount appropriated by act approved June 18, 1878	$20,000 00
July 1, 1878, amount available	20,000 00
Amount (estimated) required for completion of existing project	100,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880	100,000 00

M 4.

IMPROVEMENT OF MISSOURI RIVER OPPOSITE SAINT JOSEPH, MISSOURI.

The allotment of $10,000 for this work from the general appropriation for improving the Mississippi, Missouri, and Arkansas Rivers (act approved August 14, 1876) was expended during the past season in protecting the shore near the dikes already in place and in strengthening the dikes themselves. A full report of these operations, with an accompanying map, was submitted to you May 29, 1878.

During the present season it is proposed to carry a mattress revetment along the exposed shore as far as the means at our disposal will allow.

This revetment will extend from 4 feet above low-water mark to such a distance along the bed as will insure against undermining.

The work is situated in the collection-district of New Orleans, and the nearest port of delivery is Omaha, Nebr. The nearest fort is at Leavenworth, Kans.

Amount of revenue collected at Omaha, Nebr., during fiscal year ending June 30, 1878, was $2,364.44.

Money statement.

July 1, 1877, amount available	$9,098 81	
Amount appropriated by act approved June 18, 1878	50,000 00	
		$59,098 81
July 1, 1878, amount expended during fiscal year		9,098 81
July 1, 1878, amount available		50,000 00
Amount (estimated) required for completion of existing project		18,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		18,000 00

M 5.

IMPROVEMENT OF MISSOURI RIVER AT NEBRASKA CITY, NEBRASKA, AND EASTPORT, IOWA.

The allotment of $15,000 for this work from the general appropriation for improving Mississippi, Missouri, and Arkansas Rivers (act approved August 14, 1876) was expended during the past season in accordance with the plan set forth in my letter of May 22, 1877, published in your Annual Report for 1877, Appendix M 4.

The small amount of money available rendered it necessary to adopt some cheap and temporary style of construction by which it was hoped that some useful results would be obtained. It had been previously determined that the cheapest mode of effecting the desired improvement would be to change the direction of the channel current, instead of endeavoring to directly protect the bank which was being eroded. The amount allotted not being sufficient to justify any solid construction, it was decided to build a floating dike from the Iowa shore at the head of Copeland's Bend, a detailed description of which will be found in the appended report of Mr. Max Boehmer, assistant engineer, who had charge of the work.

To get the best effects from a work of this kind, it is necessary that it should be in position during a flood stage of the river, when the quantity of sediment is a maximum. When the dike was built the season was so far advanced that the river was at a log stage, and there was no rise of importance before the ice began running. This, of course, carried away the buoys which kept the dike afloat and allowed it to settle on the bar that it had formed. An examination in the spring showed that the brush was still in place and exerting a marked influence on the direction of the channel, which had been moved quite a distance in the direction desired. The erosion of the bank near the dike had also been stopped. What the effect of the great flood now prevailing will be remains to be determined, but I regard the results obtained last fall as being very satisfactory. Under more favorable conditions, and especially with longer experience in making and placing the so-called weeds of which this dike was composed, I think that very valuable results can be obtained on the Missouri at comparatively small cost, and there is no doubt that, as an adjunct to more permanent works, the system is susceptible of a wide application.

Operations during the coming season will depend upon the data to be obtained by a resurvey of the locality, which will be taken in hand as soon as possible. As soon as the results of this survey are available a project for the expenditure of the present appropriation, with estimates for continuing the work, will be submitted to you.

The work is situated in the collection-district of New Orleans, and the nearest port of delivery is Omaha, Nebr. The nearest fort is at Leavenworth, Kans.

Amount of revenue collected at Omaha, Nebr., during fiscal year ending June 30, 1878, was $2,364.44.

Money statement.

July 1, 1877, amount available		$11,700 57	
Amount appropriated by act approved June 18, 1878, viz:			
For improving the Missouri River at Nebraska City, Nebr	$20,000 00		
For improving the Missouri River at Eastport, Iowa, and Nebraska City, Nebr	20,000 00		
		$40,000 00	
			$51,700 57
July 1, 1878, amount expended during fiscal year			11,700 57
July 1, 1878, amount available			40,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.			85,000 00

REPORT OF MR. MAX BOEHMER, ASSISTANT ENGINEER.

SAINT LOUIS, MO., *January* 18, 1878.

MAJOR: I have the honor to submit the following as a final report on the work under my charge at Nebraska City, Nebr., during July, August, and September, 1877.

The novelty of the method employed in building the dike warrants a more detailed description of the work, and makes a summary of facts and figures, as observed during the progress of the work, useful for future reference in works of a similar kind.

I therefore beg leave to submit a condensed copy of my previous reports, with additional data of importance, and figures arranged in shape for easy reference.

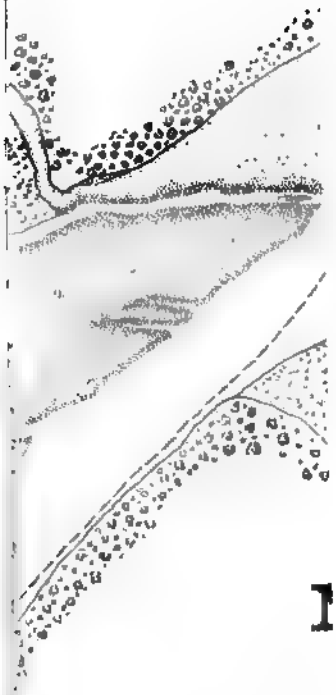
The dike built is the first one of a system intended to restore the harbor and river frontage to Nebraska City, and at the same time to save the Iowa shore opposite from further encroachment.

Owing to the small amount available for the work, it was thought best not to attempt the construction of a solid dike, but to adopt a plan less costly in the shape of a floating dike. Orders were given, therefore, for the construction of a dike of "Brownlow weeds," after the pattern of works of the same order built on the rivers in the East Indies by English army engineers. The weeds derive their name from their inventor, Colonel Brownlow, R. E. A description of this system is given in the "Professional Papers on Indian Engineering" (second series), April, 1875, article No. 152, "Report on Sutlej River Training Works," by H. C. Graham, esq., executive engineer.

A number of small trees or a lot of brush is tied to a rope, and this entire bunch is fastened to a float, anchored in the stream by means of sacks or a net-work filled with brick or stone. When first put in this brush will float, but gradually collecting sediment, its lower end will sink to the bottom, while the upstream end is held up by the buoy, the whole contrivance thus presenting an obstruction to the flow from the surface to the bottom, and disturbing every thread of the current passing through it. The intended effect is to retard the current, and to cause a partial deposit of the sediment carried in suspension by the stream. This, done on a large scale, will create bars, and the water displaced is forced to take the new channel designed for it outside of the obstruction. [See accompanying sketch No. 1.]

In the work at Nebraska City a change was made in the construction of these weeds. Instead of using two ropes, as in the original, one the main rope with the brush, and the other as anchor-line, the relative positions of the parts were reversed, and one of the ropes dispensed with entirely, by tying the brush to the anchor-line direct. [See accompanying sketch No. 2.]

This change was made, not only for economical reasons, but also, and principally, because a cold climate made such change necessary to prevent the ice from carrying away the entire structure. And this would surely have happened if the original plan had been adhered to. A glance at the sketches will show the difference. In the old



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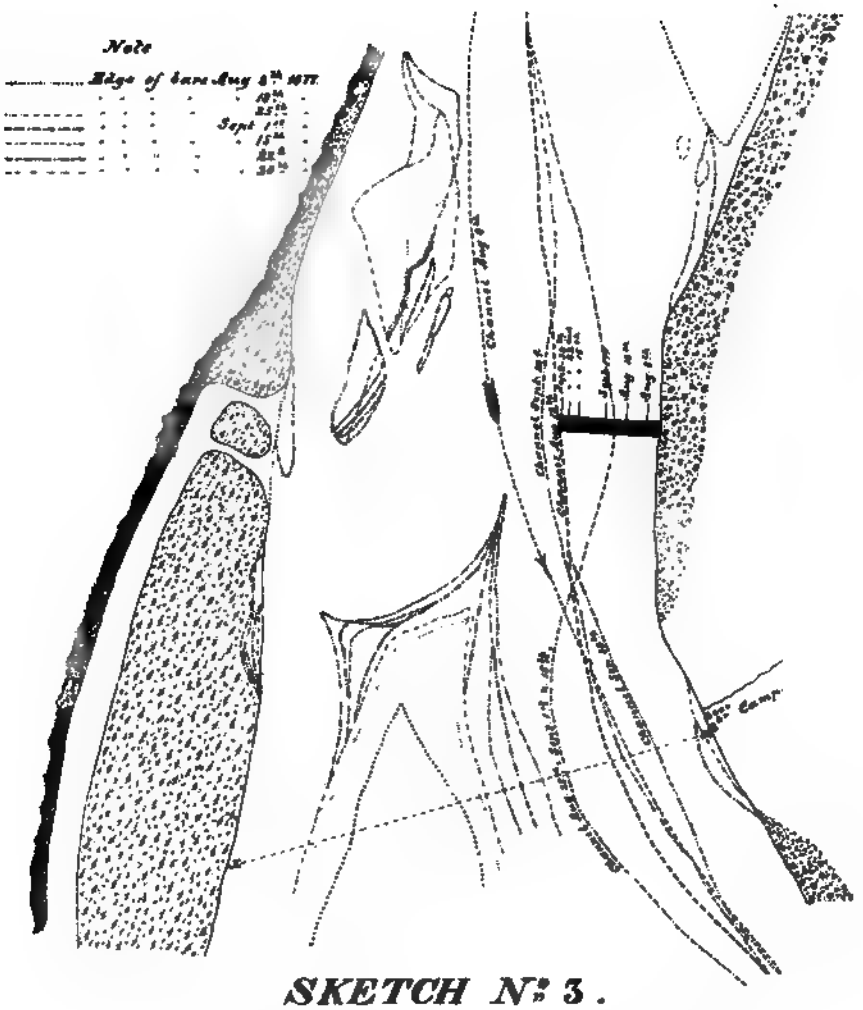
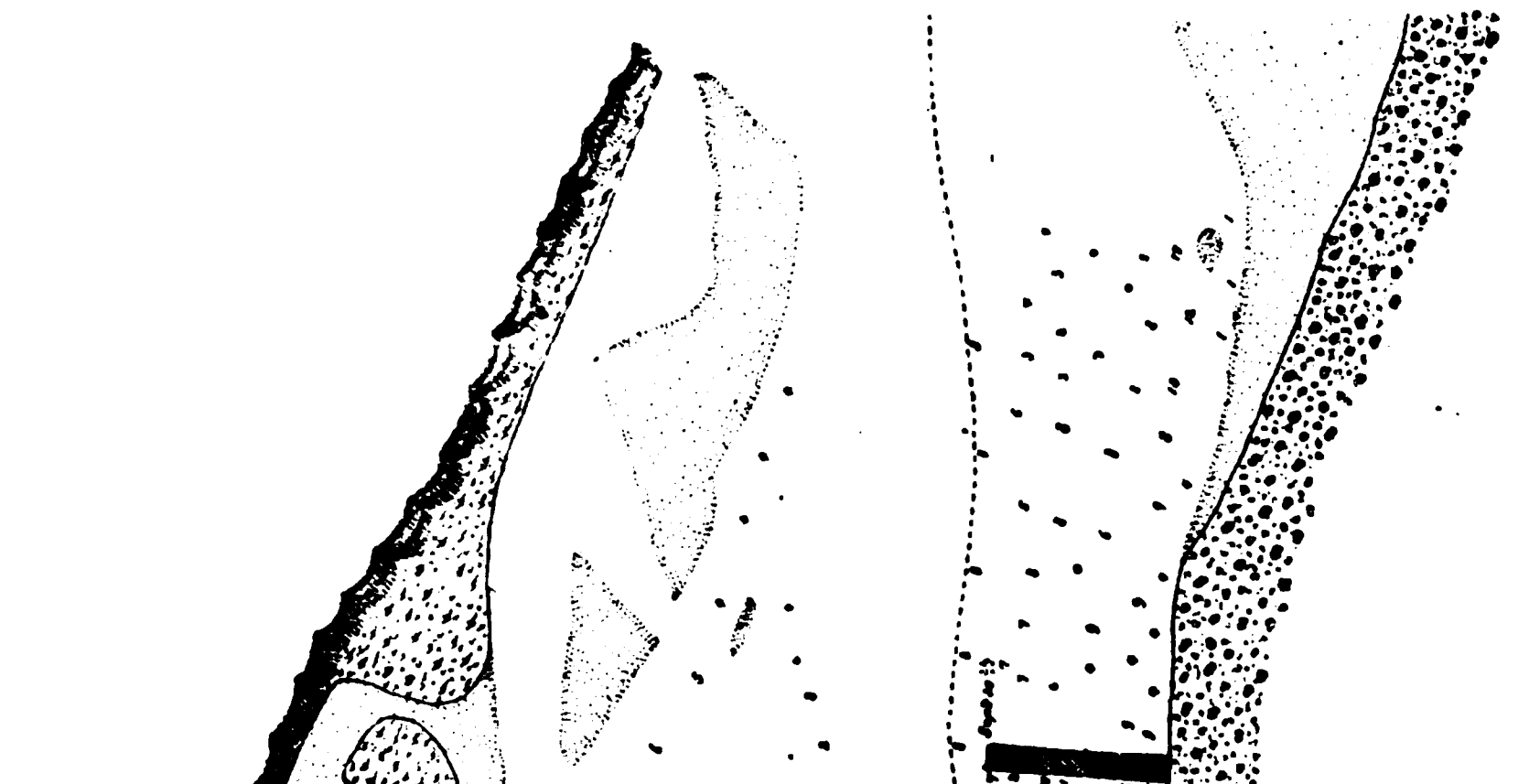


SKETCH N: 3.

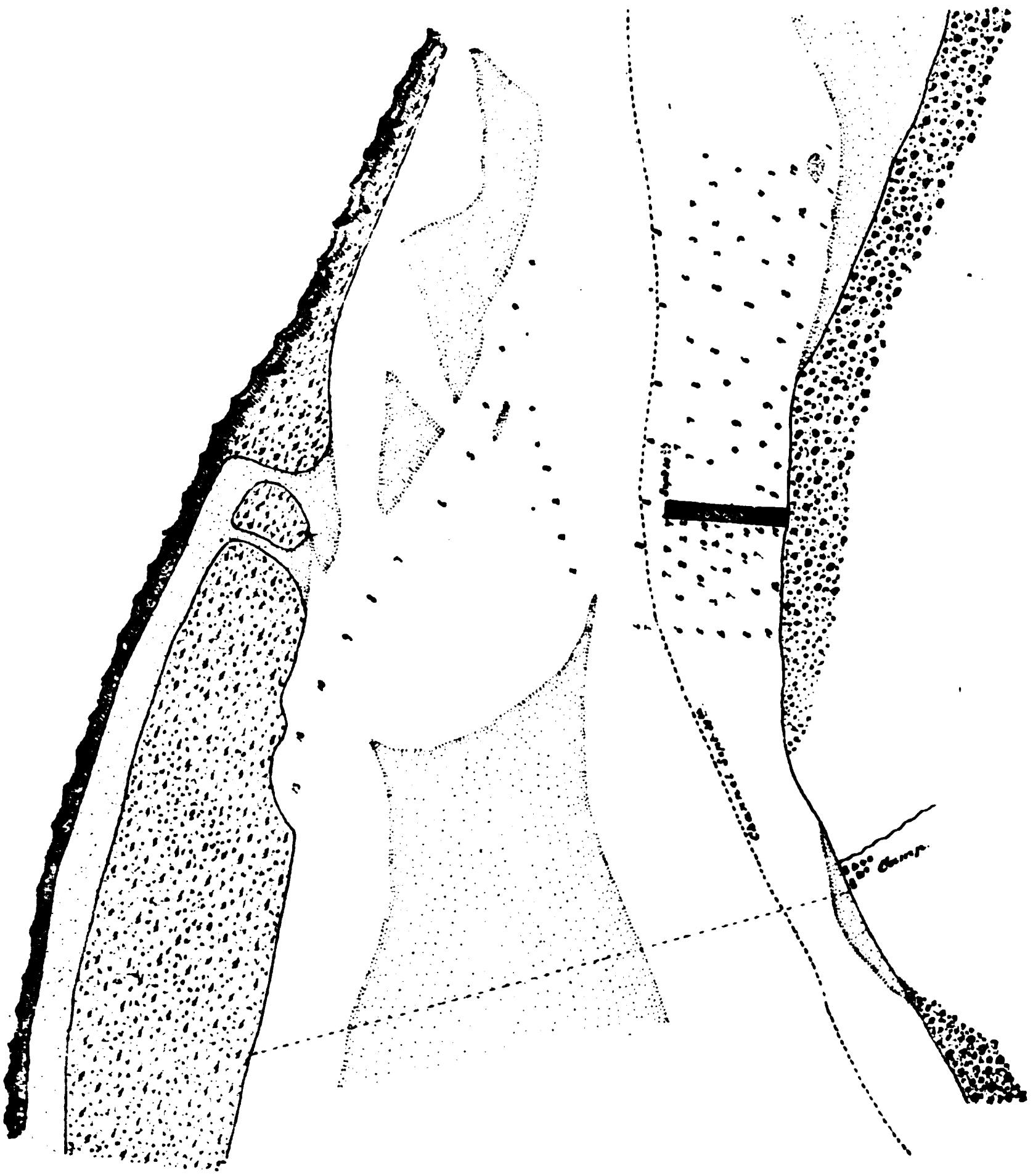
showing progress of extention of Floating Dyke near Nebraska City, Neb. and the resulting changes in outline of bars and banks.

Scale



SKETCH N: 4.

showing progress and soundings in vicinity of Floating Dyke
near
Nebraska City, Nebraska.
on the 30th of September 1877.
Scale



SKETCH N: 4.

showing progress and soundings in vicinity of Floating Dyke
near
Nebraska City, Nebraska.
on the 30th of September 1877.
Scale

plan the running ice would cut off the anchor-line, and consequently carry away the brush also, while in the changed weed the ice will simply cut off the float and leave the brush in position. This, of course, destroys the working power of the structure at once, but the brush remains at the bottom, and this not only prevents subsequent floods from establishing the main channel in that part of the river, but also forms a solid foundation for the work of the following season, if such become necessary.

The dike was constructed in the following manner: First, a foundation of unbuoyed weeds was laid, for the double purpose of securing the bottom from scouring and of forming a rack against which the anchors of the buoyed weeds would catch. This layer was steadily kept in advance of the regular weeds, and the latter were put in from 50 to 100 feet above it, the current dragging them downstream till the anchors caught on the foundation. It was found that without these sunken weeds to hold upon the buoyed ones could not be held in place with an anchor weighing 2,800 pounds in 15 feet of water and a 5-mile current. The pull of the current on these weeds was so terrible that, in spite of all precautions, 21 out of a total of 669 weeds were dragged beyond the dike. Some of these landed on bars more than a mile below, although most of them stopped within 200 feet in the dead water behind the dike.

The deepest water (the main channel 24 feet deep) was reached at a point 250 feet from shore; here the weeds were put in thickest, but without visible effect upon the channel. The dike was continued to a length of 550 feet, and still the channel remained in the same place, over the dike. This induced me to fortify the dike still more throughout its entire length, and to good advantage, I think, since from that time the water shoaled rapidly, the bars gaining 10 feet in as many days in some places. The same result, perhaps, would have been brought about by a lighter dike in a longer space of time, but I deemed it unsafe to try it in this case, because we had to face and turn the channel itself. Under the lee of the channel, I think, these weeds can be used in smaller numbers with perfect success, and I have no doubt that in some localities, and under favorable circumstances, dikes of a similar kind may be built of half the strength and at half the cost of the one at Nebraska City.

We built out to a distance of 758 feet from shore, and, to judge from the heavy cutting of the bank and the bars opposite, it seems plausible to assert that with a dike of 1,200 feet the channel would have been turned into the slough on the Nebraska side.

When the work was abandoned, a cross-section 100 feet below the dike showed less than 2 feet of water for one-half and less than 5 feet for three-quarters of its extent. Some fissures as deep as the channel outside of the dike, but narrow, remained here and there, and these corresponded with apparent openings in the dike, where the water seemed to concentrate and run at greater speed. But this proved to be deceiving, since in all such places no breach was found, but always solid bottom in less than 4 feet of water. Such fissures in the bar below, therefore, were not caused by corresponding fissures in the dike, but were formed simply by the concentration of the water after it had passed the dike.

The surface of the water above the dike when finished was 6¼ inches higher than that below it. This elevation was plainly visible to the eye, and proved to be a safe guide in building every part equally strong. Wherever this appeared less marked there was a weak place in the dike, and more weeds were put in.

To judge of the depth by the velocity of the current, or by the width of water-way between the brush on the surface, was impossible, since the water rushed with the same or even greater velocity over places only 2 feet deep as through breaches 10 feet deep. Frequent soundings and the elevation of the surface were the only true guides. I speak of this because, in this particular structure, weeds thrown into shallow places are weeds wasted, and because frequently the appearance of the water was very deceiving, apparent breaches on close inspection proving to be the very strongest places in the dike.

The bars formed below the dike consisted mainly or altogether of clay, while those above invariably were composed of sand only. A rise in the river of 4 inches was sufficient to deepen the water on these upper bars from 2 to 3 feet in one night throughout their entire surface, while those below never suffered abrasion, but steadily advanced in breadth and in height. The large quantities of sand which on such occasions were carried through the dike passed on beyond without visibly adding to the bars below it. This sand must have all been carried through the deep fissures of the lower bar, because on the shallow places there was absolutely no current whatever; an eddy, even, in some instances.

After the completion of the work a watchman was left to guard the floats from being cut off and stolen, so as to keep the dike at work as long as possible. On December 4, 1877, this watchman reported that the ice had cut away all the floats, but that the brush remained, and that the bars seemed to be still growing. He reported that to cross the river in a skiff from the Iowa shore, he had to go over one-fourth of a mile below the dike. This shows that the bar below must have gained at least 600 feet in length in six weeks' time.

It is impossible to tell the permanent effect of the dike until after the next high-

water has passed over it. I believe that it will stand the pressure, and its resistance may prove sufficient to throw the channel where it is designed to be, through the slough on the Nebraska side. The amount of water in this slough had been increased 7 per cent. during the work, and seemed to be steadily, though very slowly, gaining. As yet the main channel passes on the outside of the dike and whips back to the Iowa shore as soon as the bar below will admit. As this bar is steadily advancing downstream, it will in time probably result in keeping the channel away from the Iowa shore entirely. But this is not enough. The first dike of the system contemplated must throw the low-water channel into the Nebraska slough for a successful execution of the whole plan. The effect of the next high water must be awaited before it can be decided whether more work is necessary on this dike, and especially whether it should be extended farther into the stream.

The details of the work are given below under their different heads.

Weeds were made out of ropes 50 feet long, 40 feet of brush length, and 10 feet of anchor-line. The rope was laid on the ground and a layer of brush tied to it; then the bunch was rolled over and a second layer added. The average amount of brush in each weed was 2.6 cords. The brush was tied to the rope with one string of spun yarn, equal in strength to about four strands of ordinary rope.

Ropes.—All the rope used was "sisal rope."

Main line of "foundation weed" ..... = ¾-inch diameter.
Main line of "buoyed weed" ..... = ¾-inch diameter.
Rope around float ..... = ⅝-inch diameter.
Buoy tied to weed with = double ..... = ½-inch diameter.
Rope around sacks ..... = ½-inch diameter.

Anchors.—Anchor to "foundation weed" = 5 to 7 sacks stone.

Anchor to "buoyed weed" = 9 to 11 sacks stone.

Weight of single sack = 240 to 280 pounds.

Average anchor = 19 cubic feet loose rock = 12.7 cubic feet solid rock = 2,121 pounds.

Floats.—Second-hand barrels delivered at ..... $1 25 each.
Calked boxes, 16 inches by 16 inches by 4 feet, pine, at ..... 75 each.
Calked boxes, 16 inches by 16 inches by 4 feet, cottonwood, at ..... 65 each.
Buoyancy of float ..... = 400 pounds.

Brush, mostly dogwood, 8 to 16 feet long, cost = $1.05 per cord.

Stone.—Bastard limestone, weighing 167 pounds per cubic foot, cost = $1.85 per cubic yard, loose. Brought in small flat-boats from the opposite shore, one mile above.

Number of weeds planted	=	669
Total brush-length of weeds ..... feet ..	=	27,142
Cost of one weed, placed	=	$11 30
Length of dike built ..... feet ..	=	758
Cords of brush in dike	=	1,700
Cubic yards of stone in anchors	=	466
Cost of linear foot of dike	=	$10 00
Number of weeds to linear foot of dike	=	0.85
Fall of surface over dike ..... inches ..	=	6¼

Greatest effect observed = deposit 19 feet deep in 24 feet of water in 6 weeks' time.

Strongest current in river = 4½ miles per hour; strongest current over dike = 7 to 8 miles.

PERCENTAGE OF COST OF DIKE-CONSTRUCTION (EXCLUSIVE OF SHORE PROTECTION).

	Per cent.
Brush	24
Stone	11
Rope	23
Buoys	4
Boats, tools of contingencies	10
Labor and superintendence	28
Total	100

Very respectfully,

MAX BOEHMER,
Assistant Engineer.

Maj. CHARLES R. SUTER,
Corps of Engineers, U. S. A.

M 6.

IMPROVEMENT OF MISSOURI RIVER AT OMAHA, NEBRASKA, AND COUNCIL BLUFFS, IOWA.

A report, with plan and estimates for carrying on work at this locality, was submitted to you on the 14th of December, 1877, and published in Senate Ex. Doc. No. 30, Forty-fifth Congress, second session.

The unusually high flood now prevailing has made great changes in the condition of affairs here, and a resurvey has been ordered to determine whether a modification of the original plan will not be necessary. As soon as I have the results of this survey, a plan will be submitted to you for the expenditure of the present appropriations, as well as estimates for continuing the work, if necessary.

The work is situated in the collection-district of New Orleans, and the nearest port of delivery is Omaha, Nebr. The nearest fort is at Leavenworth, Kans.

Amount of revenue collected at Omaha, Nebr., during fiscal year ending June 30, 1878, was $2,364.44.

Money statement.

Amount appropriated by act approved June 18, 1878, viz:		
For improvement of the Missouri River at Council Bluffs, Iowa, and Omaha, Nebr	$50,000 00	
For improvement of the Missouri River at Omaha City, Nebr	30,000 00	
		$80,000 00
July 1, 1878, amount available		80,000 00
Amount (estimated) required for completion of existing project		130,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880		130,000 00

M 7.

IMPROVING MISSOURI RIVER AT SIOUX CITY, IOWA.

A survey at this locality was made under my direction, at the expense of the city, and a report with plan and estimate submitted to you on the 23d of May, 1878.

A resurvey will be needed as soon as the present flood subsides, to ascertain whether any change of plan will be necessary before commencing the expenditure of the present appropriation. When this survey is completed, estimates for carrying on the work, if necessary, will be submitted to you.

The work is situated in the collection-district of New Orleans, and the nearest port of delivery is Omaha, Nebr. The nearest fort is Fort Randall, Dak.

Amount of revenue collected at Omaha, Nebr., during fiscal year ending June 30, 1878, was $2,364.44.

Money statement.

Amount appropriated by act approved June 18, 1878	$12,500 00
July 1, 1878, amount available	12,500 00
Amount (estimated) required for completion of existing project	33,774 00
Amount that can be profitably expended in fiscal year ending June 30, 1880	33,800 00

M 8.

SURVEY OF MISSOURI RIVER FROM ITS MOUTH TO SIOUX CITY, AND ESTIMATES FOR THE IMPROVEMENT AND MAINTENANCE OF ITS NAVIGATION.

A plan for carrying on this work by making a thorough and comprehensive survey was submitted to you, and, having been approved, the party will be put in the field as soon as practicable. It is expected that the present appropriation will be sufficient to carry the survey from Leavenworth, Kans., to the mouth of the Missouri, leaving the upper portion to be provided for by further appropriations.

Money statement.

Amount appropriated by act approved June 18, 1878	$50,000 00
July 1, 1878, amount available	50,000 00
Amount (estimated) required for completion of existing project	50,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880	50,000 00

M 9.

IMPROVEMENT OF ARKANSAS RIVER AT FORT SMITH, ARKANSAS.

The plan proposed by me for work at this place in my letter of August 15, 1877, having been approved, work was begun as soon as possible and prosecuted as opportunity afforded until the funds allotted, $10,000, were exhausted.

The works consist of a dike of brush and stone projecting 1,100 feet from the left bank above the mouth of Poteau River. From its outer end a longitudinal dike extends down stream 600 feet, the object desired being to carry the main channel to the right bank near the Poteau, to deepen the crossing over the bar, and to render the landing at Fort Smith accessible to steamboats at low water. For full details of these operations, accompanied by maps and plans, I beg to refer to the annexed report of Capt. D. W. Wellman, assistant engineer, who, with Mr. J. H. Curtis as assistant, had charge of the work.

In order to test as speedily as possible the effect likely to be produced, the height and width of the dike were kept at a minimum, but they have withstood a very heavy and long-continued flood without serious damage. During the coming season it is proposed to widen the dam and strengthen it, when necessary; also, to raise the crest 3 feet, so as to give it a uniform height of 8 feet above low water. The slant will be lengthened 400 feet. When this work is completed, it is believed that the end proposed will be accomplished, and it is not anticipated that any further appropriation will be required.

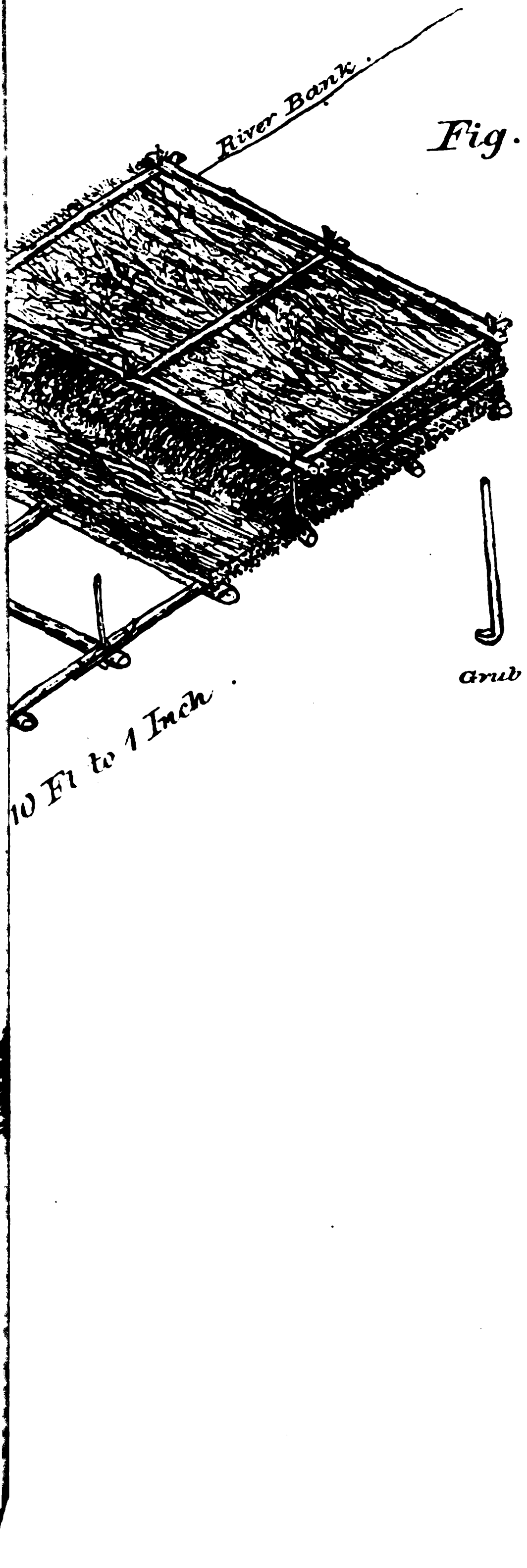
This work is situated in the collection-district of New Orleans. The nearest port of delivery is Memphis, Tenn., and the nearest fort is Fort Smith, Ark.

The amount of revenue collected at Memphis, Tenn., during fiscal year ending June 30, 1878, was $27,734.43.

Money statement.

July 1, 1877, amount available	$9,695 49	
Amount appropriated by act approved June 18, 1878	10,000 00	
		$19,695 49
July 1, 1878, amount expended during fiscal year		9,695 49
July 1, 1878, amount available		10,000 00

Fig. 3.



REPORT OF CAPT. D. W. WELLMAN, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Saint Louis, Mo., May 31, 1878.

MAJOR: I have the honor to submit the following report in regard to the work under my charge on the Arkansas River at Fort Smith, Ark.

The object of the work at this place is the removal of a sand-bar in the river in front of the town of Fort Smith, or so much of it as will permit the approach of steamboats to the landing in low water, and secure a direct ferry crossing. Heretofore, for years, in low stages, steamboats could not come within 1½ miles of the landing, and in crossing the river it has been necessary to ferry across two channels besides hauling a quarter of a mile over the bar.

In the months of May and June, 1877, a survey of the locality was made, a plan of improvement submitted, which was approved, and, in October, work was commenced. The season proved to be one of unusually high water, which greatly delayed progress, so that it was not until the end of March last that the funds available for the work were expended.

The work consists of a dike of brush and stone built out from the left-hand shore nearly at a right angle with it and opposite the head of the bar. It is extended in that direction 1,100 feet, from whence it runs down the stream parallel with its axis for a distance of 600 feet, and on to the head of the original bar. This part of the dike lying parallel with the stream is designated as the "slant." The dike is similar to those used by Col. D. C. Houston, Corps of Engineers, U. S. A., in the improvement of the Wisconsin River, and is built principally in the manner described in his report dated December 25, 1875 (Report of Chief of Engineers for 1876. Part 2, pages 402–406). The shore protection is 100 feet long, lying 50 feet above and 50 feet below the line of the dike, and is carried up nearly 22 feet above low-water mark, and within 5 or 6 feet of high water.

At the commencement, the brush for the dike was made into mats by Colonel Houston's method—first making it into fascines and then binding the fascines into mats, but later the making of fascines was abandoned as unnecessarily expensive, and the brush made directly into mats in the following manner:

Four stakes, 2 to 3 inches in diameter, were driven firmly into the ground, forming a parallelogram the short sides of which were 4½ feet and the long sides 4½ to 6 feet in length, depending on the kind of brush obtainable in the vicinity, the tops of the stakes being left about 2½ feet above the ground. Inside of this parallelogram, and touching the stakes, were laid parallel with the long sides 2 straight logs, 4 to 6 inches in diameter and 6 or 7 feet long. Across these logs, in suitable notches, near the stakes, were laid the under bands or binding poles of the mat (see Figure 1, accompanying plate). Brush was then laid on the bands between the stakes until sufficient was had for a mat, care being taken to keep the brush parallel and well up against the stakes to insure uniformity of thickness. The top bands were then laid on and bound down in the same manner as described in the report alluded to, except that the sides were not passed in, they being held in the proper place by the stakes. Figure 2 shows a mat in the frame ready for binding. These mats were 4½ feet wide and 1 foot in thickness, and contained fully twice the amount of brush per mat as those made from fascines, which were 2½ to 3 feet wide and 7 to 9 inches thick. The cost of the two kinds per mat was about the same, showing a decided difference in favor of the larger mats. For these mats almost any kind of brush—coarse, crooked, and even a mixture of thorny—can be used, whereas fascines require brush that is reasonably straight and pliable and free from thorns. Another advantage of the larger mats over the smaller ones is in the saving on stone. In sinking the larger mats, especially in deep water, much less stone is wasted by being carried clear of the mat by the current before reaching bottom.

At your request, made in February last, an experiment was tried, principally with a view to test the economy of making the brush into large mattresses, 2 or 3 feet in thickness, and floating them to place. At that time there was only one place in the line of the dike, and that less than 100 feet long, where a mattress 3 feet thick could be placed, the dike being then pretty well along, and through this contracted space the water was pouring at the rate, it was estimated, of 3½ miles per hour. A mattress was, however, made, 50 by 20 feet and 3 feet in thickness inside the binding-poles. It drew, when finished, not less than 4 feet of water, only the upper binding-poles being out of water when afloat. The manner of constructing the mattress was as follows:

A place was selected on the river-bank, 2 miles above the dike, where deep water could be found close to shore and where little shaping of the bank was necessary. Four cottonwood poles, 25 feet long and 6 to 8 inches in diameter, to be used as ways for launching the mattress, were laid end to the stream and 12½ feet apart, and inclined toward the water at an angle of 20 or 25 degrees. Five binding-poles, 20 feet long and 4 to 6 inches in diameter, were then laid 12½ feet apart, parallel with the ways, and

alternating with them, the outer poles being placed about 6 feet outside the two end ways, and were blocked up so that their upper surfaces came even with the upper surface of the ways. Through each of these binding-poles were put—one near each end and one in the middle—3 2-inch pins, of the kind known among lumbermen as "grubs." They are simply a pin with a head, and are made from a green sapling, the head being formed from a portion of the root, which is left on in cutting the sapling, and are put in from the under side. In this case the grubs were 4 to 5 feet long. Poles, 3 to 4 inches in diameter and about 28 feet long, were then laid across the binding-poles and along the lines of the grubs, lapping past each other 4 or 5 feet in the middle. Some of these poles were bored and slipped onto the grubs at the ends and middle to hold the mattress from pulling apart lengthways, and all the intersections bound tightly with fence-wire; also the poles where they lapped in the middle were wired together, the whole making a very strong frame, into which brush was piled, first across the last-laid poles for about a foot in thickness; then a layer in the other direction, and finishing with another cross-layer on top. Poles were then laid on the top, corresponding to those on the bottom, the longer ones first and the shorter ones last, some of the longer and all of the shorter poles being bored and slipped onto the grubs, and the whole bound down and strongly wedged. Figure 3 of the plate shows manner of making the frame arrangement of the brush and method of binding. It was then launched by slipping it off the ways with hand-spikes, fastened to a scow, and floated to place. Some difficulty was experienced in floating it down the channel along which it was obliged to be taken; being shallow, it grounded several times and had to be pulled over with a capstan on one of the stone-barges. Great care was taken as it approached the dike to guard against its being carried over by the current. The side of the mattress which was to lie up stream when in place was brought alongside the scow and raised by means of lines and levers as much as possible out of the water, in order to present the least surface to the current, and firmly lashed to the scow. It was then slowly let down into position, but, notwithstanding the precautions taken at the first trial, the anchorage gave way, and the mattress and scow went over the dike. It was, however, readily landed just below, and the next day, there having been over night a rise of about a foot in the Potean, without a corresponding one in the Arkansas, and which consequently had a tendency to slacken the current at the dike, it was hauled back, additional anchors put out, and the mattress sunk in its place without further difficulty. In addition to the lashings to hold the up-stream edge out of the water, lines were run from the scow to the down-stream side, for the purpose of preventing any movement of the mattress down the stream when the upper lashings were cut to allow it to sink. The stone for sinking it were placed on the scow to which the mattress was attached, and, when in position, were thrown onto the mattress, loading heaviest on the up-stream edge, until the lashing showed signs of giving way, when they were cut simultaneously, and it went to the bottom.

The cost of this mattress in place, not including cost of stone, engineering, and expense of foreman and boatman, who were engaged on other work in the mean time, was as follows:

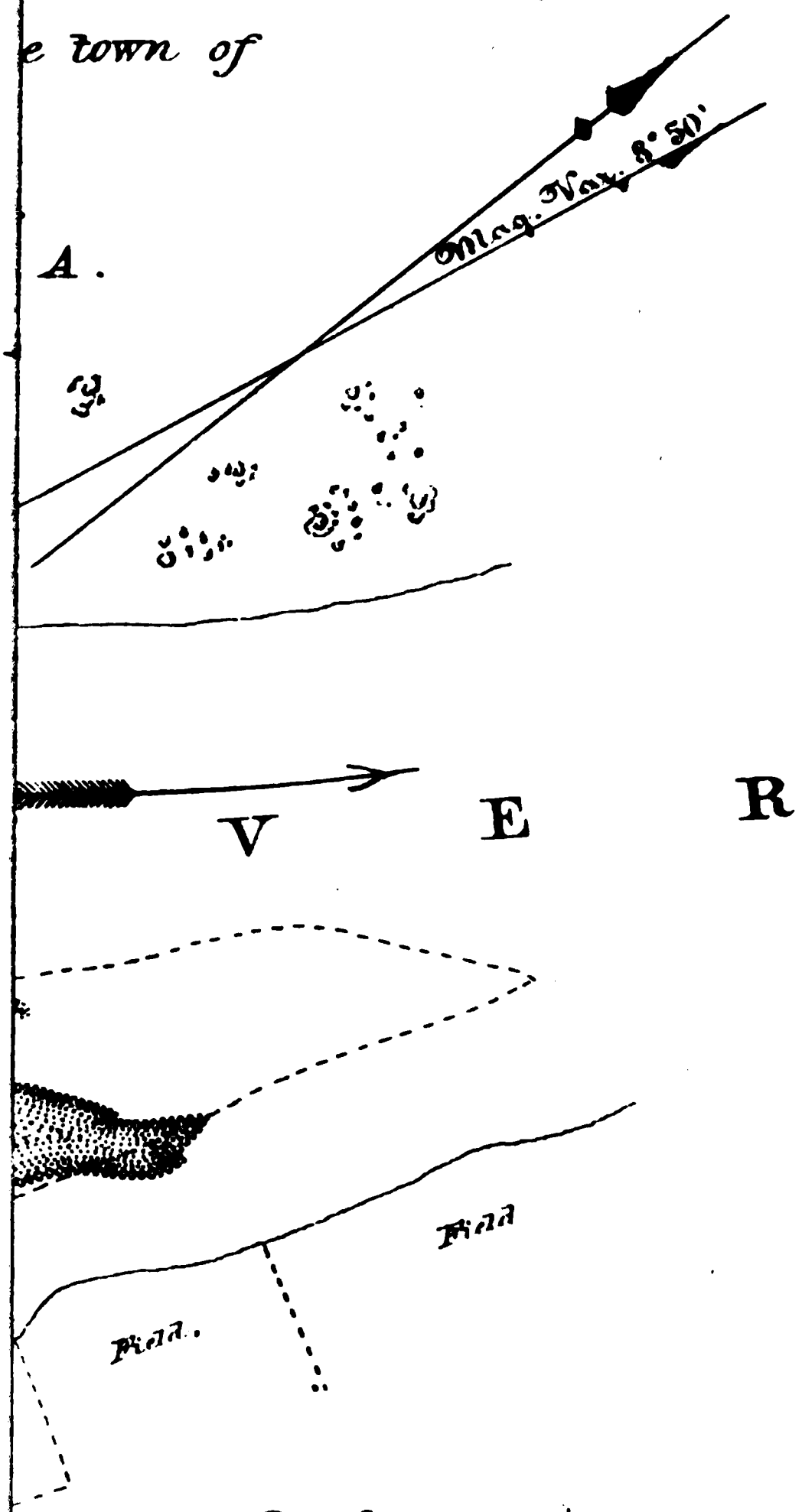
Labor on mattress	$29 50
Wire	1 00
Rope for lashing (cut and lost)	2 00
Labor and boats towing to place and sinking	25 00
Total	57 50

or 1.9 cents per cubic foot.

The cost of a mat 4½ by 10 by 1 foot placed in the dike, leaving out the same items of expense as above, does not exceed 70 cents; or less than 1.6 cents per cubic foot.

It is probable, however, that the cost of the large mattress was in excess of what would be the average cost of a large number where the proper preparation could be made for working to advantage. The proportion of stone also required with the large mattresses is considerably less than with small mats, but the small amount of work done does not give sufficient data to enable a reliable comparison to be made. For extensive works in deep water and moderate current I have no doubt that with proper appliances for handling the large mattresses would be the best and cheapest, but for light works, in a shallow stream like the Arkansas, I consider the small mats preferable.

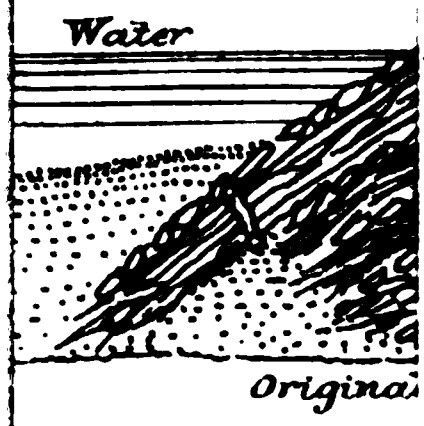
Besides the large mattress, there were placed in the dike 2,497 mats of the smallest size mentioned above, 645 mats of the larger size, and 1,053.24 tons of stone. Its total length, calling the shore protection equivalent to 100 feet of dike, is 1,800 feet, and average height about 5 feet. The stone was purchased at $2 per ton, delivered on barges at the dike. The mats were made chiefly by day's work; a few were purchased ready made, at 30 and 35 cents each. Ten dollars per barge-load was paid for loading and transporting mats to the dike; the average number of mats in a load was 78. The price paid for stone and transportation of mats included the use of barges on the work, with necessary rigging, anchors, lines, &c.

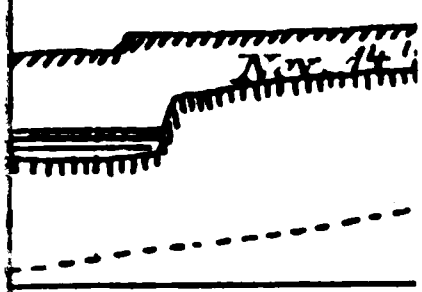


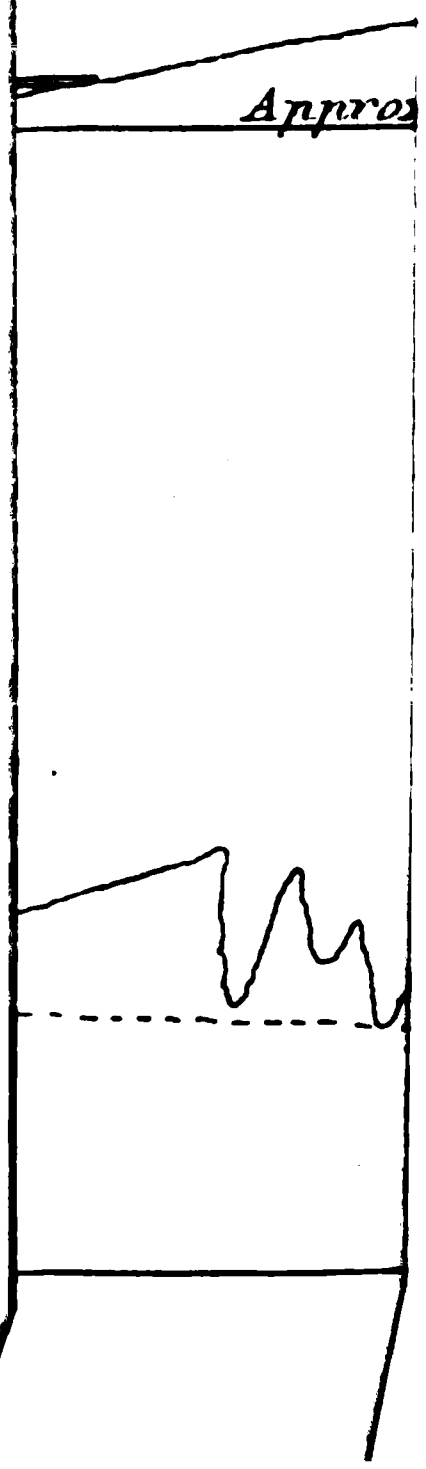
Explanation.

Edge of bars June 1877.
. . . Oct 10th .
. . . March 25th 1878

SECTIO







The total amount expended on the dike, from the commencement of the work in October, 1877, up to March 31, 1878, was $7,053, making the cost per linear foot $3.92.

The accompanying maps, Nos. 1 and 2, show the location and the progress of the work, together with its condition March 25, 1878, and the effect produced on the bar up to that date. A cross-section of the dike, designed to represent its general construction and the deposits of sand above and below the main dike, which in several places accumulated as fast as the dike was raised, is also shown.

As was anticipated, the effect of the works has been to carry away the upper end of the bar, and the main channel of the river, which before the commencement of the work crossed from the right to the left bank above the site of the dike, now crosses a quarter of a mile farther down, enabling the ferry-boat to cross directly from the mouth of the Poteau. This change took place principally during two floods, of a few days' duration each, which occurred in January and February last. There has been a heavy rise recently in the river, but what further change, if any, has been made I am not informed.

It is desirable that this scouring away of the bar should continue until the main channel crossing is brought down to nearly opposite the public landing. It is believed that when this is accomplished the nature and conformation of the shore above the landing will render the channel permanent. It is probable that the slant of the dike may have to be continued down the stream before sufficient of the bar will scour away to effect this, but just how much cannot be determined until the full effect produced by the work in its present condition can be observed.

As stated in my report on the condition of the work, dated February 21, 1878, the dike has been made as thin as was thought prudent, in order, with the means at command, to raise it as high as possible so that an immediate effect might be produced by the changed current.

During the whole of the month of February and until the middle of March the water did not get below 9 feet of the gauge, so that the last of the mats were laid in from 2 to 8 feet of water. The consequence is that the top of the dike is uneven and has doubtless many weak places. It should be raised and strengthened and finished with a face mat as shown in the cross-section of the dike throughout its whole length. At present, face mats are laid only on the lower portion of the slant, and a short distance on the main dike at the angle. The dike should be finished when the top is above water, so that it can be made level and uniform and all interstices filled with small brush and stone. It may also be found necessary, in order to secure a more direct crossing of the channel over the bar and guard against possible change in its direction, to build a short dike out from the right bank below the steamboat-landing. This necessity cannot well be determined until the slant has been lengthened and the channel has had time to establish its bed.

I desire in this to acknowledge my indebtedness to Mr. E. C. Hinman, of Portage City, Wis., who for several years has had charge, under Colonel Houston, of the construction of similar dikes on the Wisconsin River, for valuable suggestions and advice in regard both to the location and construction of this work. I am also indebted to Mr. John H. Curtis, my assistant, for efficient and intelligent co-operation, and to Mr. Duncan McCauslin, foreman of construction, for great energy, activity, and zeal in the discharge of his duties.

Very respectfully, your obedient servant,

D. W. WELLMAN,
Assistant Engineer.

Maj. CHAS. R. SUTER,
Corps of Engineers, U. S. A.

M 10.

IMPROVEMENT OF WHITE RIVER AT BUFFALO SHOALS, ARKANSAS.

At the date of the last annual report a survey was in progress at this locality; upon its completion a plan for the expenditure of the $10,000 appropriated by act approved August 14, 1876, was submitted September 3, 1877, and approved by you.

This plan contemplated the construction of 7 spur-dikes of stone, so located as to pond up the water on the places of least depth, and also the removal of rock and bowlders from a channel of 200 feet in width. This shoal is a rapid about 1¼ miles long. The fall is 7.1 feet per mile, and the low water depth is 6 inches.

Much delay was experienced owing to the continued high water, and also on account of the difficulty of procuring labor in the neighborhood. Owing to these delays the cost of the work was greatly increased. Only three of the dikes proposed have been completed, but the results obtained have been very satisfactory. The work of clearing out loose rocks from the channel is now in progress, and will be continued until the remaining balance of the appropriation is expended. It is much to be regretted that the failure of Congress to renew this appropriation will necessitate leaving the work in an incomplete state. At present this shoal is the gauge for the navigation of the upper portion of White River, and if improved would materially benefit the inhabitants of the adjacent country. It is estimated that to complete the work as proposed will require $10,000, which can all be expended in one season.

For full details of the work I beg leave to refer to the report of Capt. D. W. Wellman, assistant engineer, who, with Capt. J. D. McKown as assistant, had charge of the improvement.

New Orleans is the collection-district in which the work is situated, and the nearest port of delivery is Memphis, Tenn. Fort Smith, Ark., is the nearest fort.

The amount of revenue collected at Memphis, Tenn., during the fiscal year ending June 30, 1878, was $27,734.43.

The commerce of the country adjacent to the river is commensurably large to the existing facilities for transportation. Its amount cannot be even estimated, as much is transported by teams from the upper country to stations on the Saint Louis and San Francisco Railroad.

Money statement.

July 1, 1877, amount available	$9,816 67
July 1, 1878, amount expended during fiscal year	8,140 17
July 1, 1878, amount available	1,676 50
Amount (estimated) required for completion of existing project	10,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880	10,000 00

REPORT OF CAPTAIN D. W. WELLMAN, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Saint Louis, Mo., June 30, 1878.

MAJOR: I have the honor to submit the following report regarding the improvement at Buffalo Shoals, on White River, Arkansas, for the fiscal year ending June 30, 1878.

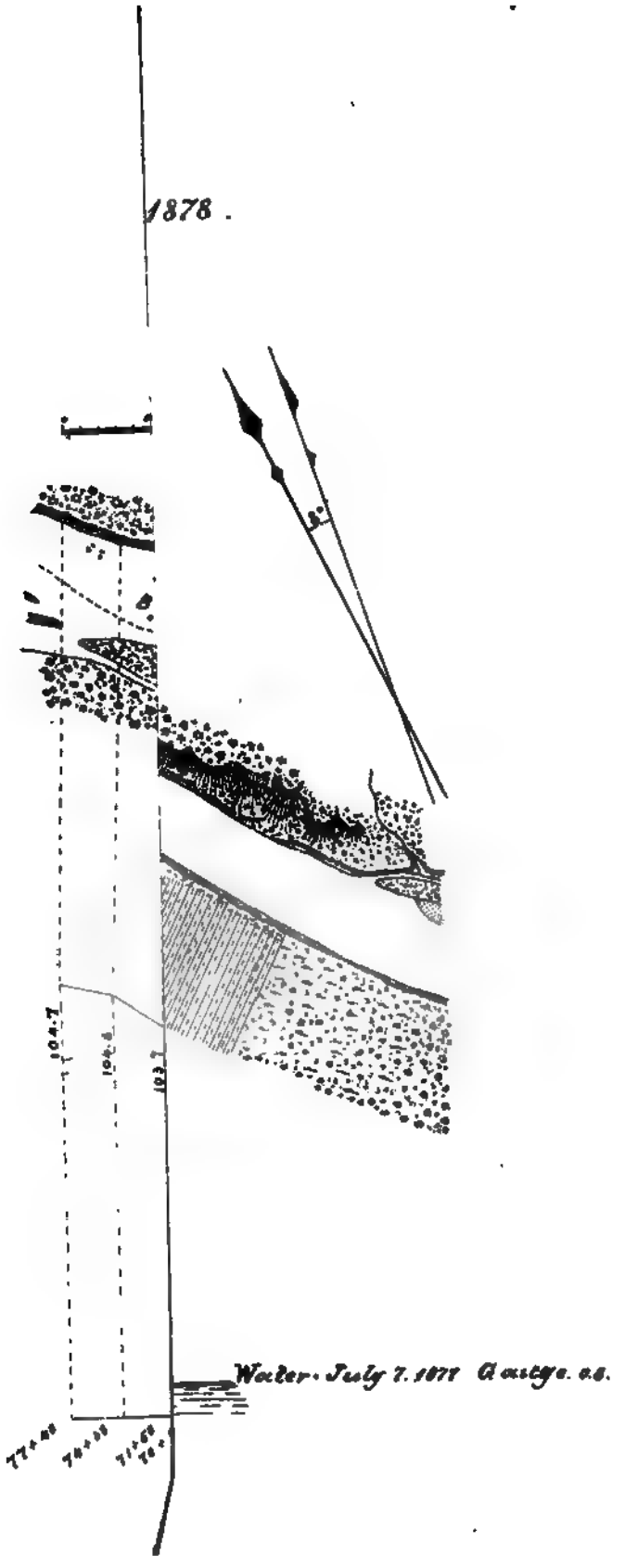
Buffalo Shoals is a wide rapid about 6,500 feet in length, the water flowing over a solid rock bottom, and falling at the rate of 7.1 per mile. The obstructions to navigation are the shallow water occasioned by the swift current and extra width of river, and large detached masses of rock scattered over the bottom.

In June and July, 1877, a survey of the locality was made, and a plan of improvement submitted, which was approved, and in October a small party, under charge of J. D. McKown, assistant, was sent up to commence the work. They arrived on the ground on the last of the month, and began preparations, but, owing to delays occasioned partly by the difficulty of procuring labor and team-work in that sparsely settled country, but principally by high water which prevented any attempt at work in the river for several weeks, it was not until the 20th of December that the work of the improvement was actually commenced. In the mean time, however, material for the dikes had been accumulated on shore to some extent.

The plan of improvement, as decided on, was to clear a channel 200 feet wide of the loose rocks, and to raise the water on some of the most shallow places by means of loose stone dikes built out from the shore.

It was the intention to first clear the channel of loose rocks, but the water remained so high that at no time during the year was it possible to do anything at that work, and attention was accordingly turned to building the dikes; but, on account of delays from the unprecedentedly high water during the whole winter and spring, only three of the dikes have been completed.

On the accompanying map, reduced from the map of the survey of 1877, the full


1878.
Water. July 7. 1877 Gaulge. as.

black lines show the location of the dikes completed, and the dotted lines those proposed. The broken line along the bed of the stream shows location of the channel it is proposed to clear, and is principally along the present deep-water channel.

The dikes are built of loose stone, laid as compactly as practicable, in 1 to 6 feet of water, and as large as could conveniently be got and handled.

Dike No. 1 is 170 feet long, and finished with a T at the end. It is 4 feet wide on top, slope of the upstream side 1 to 1, and 2 to 1 on the downstream side, and is about 6 feet high, the top being 3 feet above low water.

Dike No. 2 is 275 feet long, 4 feet wide on top, slopes same as in No. 1, and 3½ feet high, being 3 feet above low water. When this dike was completed the water on the upper side stood even with the top; the difference of level of the water above and below the dike was then 2.6 feet. I saw it at a subsequent period when the water in the river was within a foot of low water, and estimated the difference of level above and below the dike at 1.5 feet.

Steamboatmen are particularly pleased with the effect of this dike, it having raised the water in low stages at least a foot on the most difficult place to pass on the shoals.

Dike No. 4 is 110 feet long and built in the same manner as Nos. 1 and 2. The last dike (No. 4) was finished in March last, and soon after, a rise of over 20 feet occurred in the river. Dikes Nos. 1 and 4 stood perfectly. On No. 2 some of the top stones were moved by the heavy drift which was carried over it by a very strong current. These are being replaced with the largest stone that can be handled.

The cost of the work already done has considerably exceeded the expectation, principally owing to the delays already mentioned and partly to an underestimate of the cost of procuring stone and placing it in the dike. It was supposed that stone could be hauled by teams along the lines of most of the dikes, but this was found impossible (except for a few days) on account of high water. As it was, most of the stone had to be hauled to the bank, and then loaded on a scow and taken to the site of the dike. The tremendous current most of the time also rendered the handling of the scow very slow and difficult.

On the 31st of March, finding the funds remaining barely sufficient for clearing the channel of the worst bowlders when the river should fall, all work was suspended.

On the 1st of the present month Mr. McKown, assistant, again started for the shoals to commence the work of clearing the channel, but up to this date the water has been too high to allow anything to be done.

From the cost of the work already done, I estimate that to complete the dikes proposed will require the sum of	$7,000 00
For clearing channel of loose rock	1,500 00
Also for blasting on ledges to make a uniform channel over the shoals at ordinary boating stages of 2½ feet	1,500 00
Total	10,000 00

In the estimate here made, only such improvement of the shoals is contemplated as will bring them to a condition similar to that of the river above and below. Further than that it will be useless to expend money until a comprehensive system of improvement for the whole river is undertaken.

Very respectfully, your obedient servant,

D. W. WELLMAN,
Assistant Engineer.

Maj. CHAS. R. SUTER,
Corps of Engineers, U. S. A.

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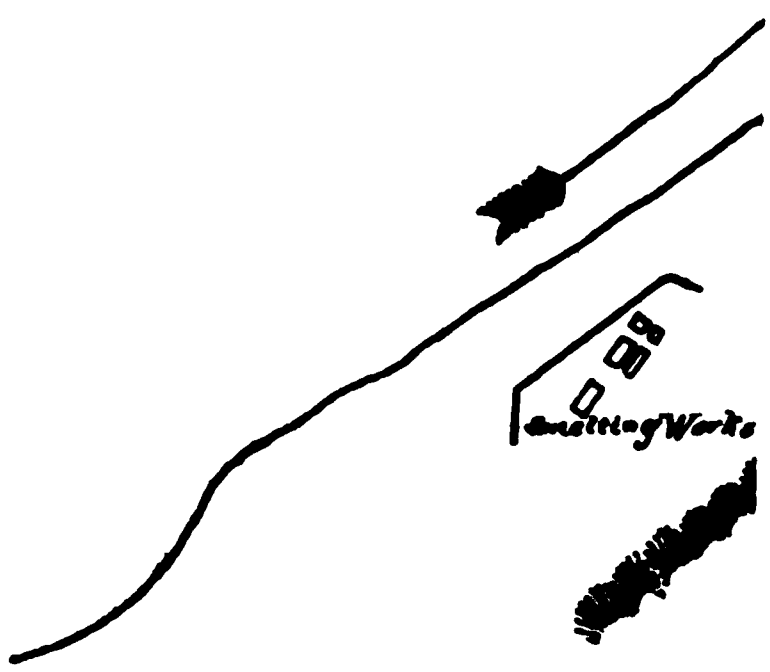
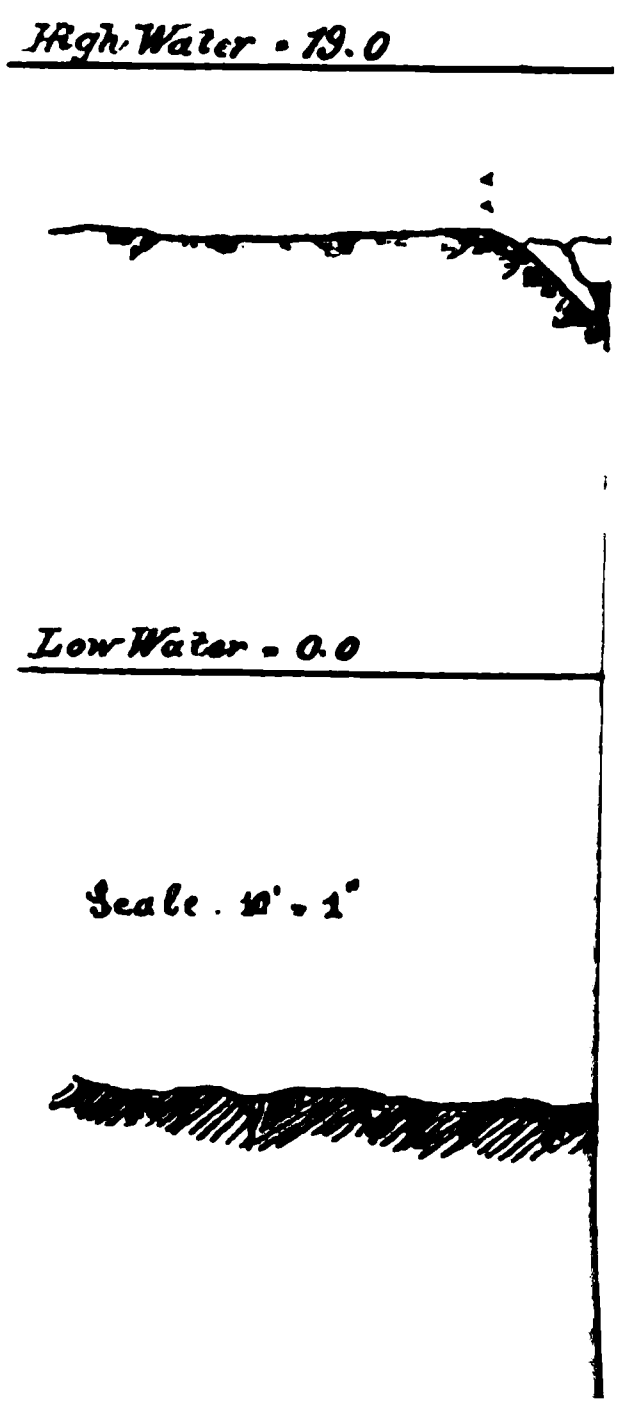
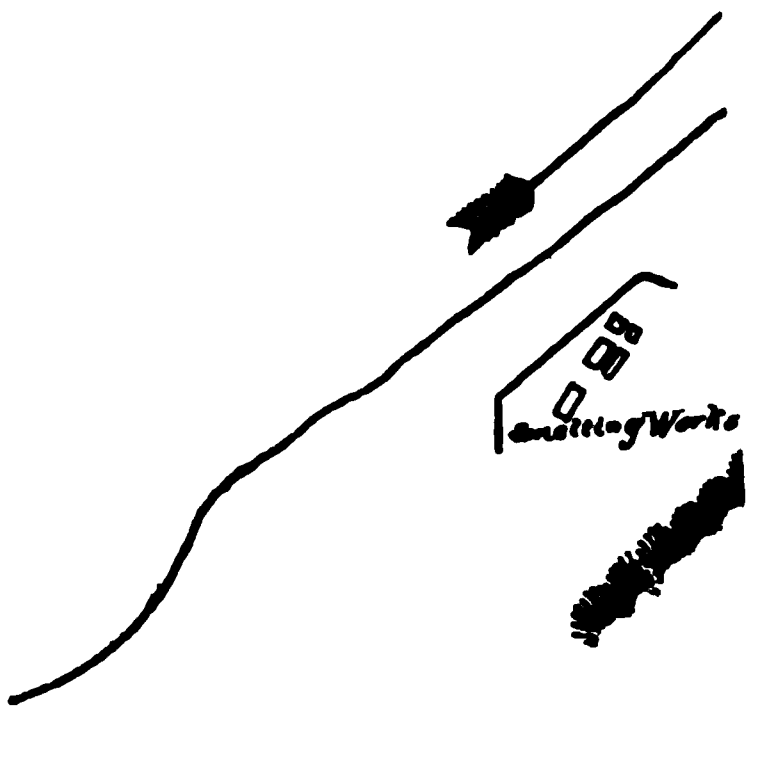
SURVEYS OF MISSOURI RIVER AT OMAHA, ATCHISON, PLATTSMOUTH, AND BROWNVILLE.

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., February 14, 1878.

SIR: The river and harbor act of August 14, 1876, contained an item making an appropriation of $100,000 for the improvement of the Mississippi, Missouri, and Arkansas Rivers, with a proviso "That $40,000


Smelting Works


High Water - 19.0
Low Water - 0.0
Scale . 10' - 1"



High Water - 19.0

Low Water - 0.0

Scale. 10' - 1"

lready made at Nebraska City, a distance of 33 miles, at an estimated ost of $3,000.

The views and recommendations are concurred in.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brig. Gen. and Chief of Engineers.

Hon. GEO. W. MCCRARY,
Secretary of War.

SURVEY OF MISSOURI RIVER AT OMAHA, NEBRASKA.

UNITED STATES ENGINEER OFFICE,
Saint Louis, Mo., December 14, 1877.

GENERAL: In accordance with your instructions of April 30, 1877, I ispatched a party to Omaha, Nebr., on May 19, to make a survey of the Iissouri River at that point, with a view to determining whether it were ossible to prevent the formation of a threatened cut-off, and generally o protect the banks in the neighborhood from the encroachments of the iver. At the time this survey was made the water was already flowing ver the neck in several places, and before the subject could be consid-red the river broke through.

During the month of November another survey was made, and the esults of the two surveys are set forth on the map which accompanies his report. The cut-off was formed July 8, and a very violent erosion egan at the apex of the new bend, threatening all the low ground in ront of the bluffs, with the car-shops of the Union Pacific Railroad and ther buildings erected on it, as well as the western approaches to the ridge. The danger was met by the Union Pacific Railroad Company, ho constructed a loose stone revetment along the portion of the bank ost violently attacked, and succeeded finally in checking the erosion ntil the falling of the river removed the immediate danger. It is, how-ver, pretty certain that at the next flood-stage the cutting will be re-ewed, and there is no telling when it will stop. The river is yet in a ery unstable condition, the slope being inordinately great and the urvature of the bend excessive. I do not, therefore, consider that it ould at present be practicable to attempt the permanent rectification f the channel, but would recommend that any work done be solely irected to prevent any further changes which may seem likely to prove njurious. I consider that the first and most obvious necessity is to pre-ent any further encroachments on the Nebraska shore above the bridge. f this is done it is probable that the whole bend will move downstream, nd this should be allowed to take place until the channel strikes the ine of the bridge at right angles. As soon as this is accomplished the owa shore above the point will have to be held. No estimates for this ork can yet be submitted, and, as the work may not be needed for seve-al years, I have confined my estimates to the protection of the Nebraska hore above the bridge.

The report of my assistant, Mr. Boehmer, will give all the facts neces-ary for a full comprehension of the subject. I have submitted a differ-nt plan for the work required, because I do not consider it solely a natter of protecting any particular structures on the low ground between he bluffs and the river, but that the problem is more especially the broad ne of preventing the river from taking a shape that will throw the hannel obliquely across the line of the bridge and render it impassable

for steamboats. I recommend that the revetment already begun by the Union Pacific Railroad Company be extended in both directions, about 4,000 feet below and 1,000 feet above their work, using for this purpose fascine mattresses, loaded with stone, as has been done under my direction at Saint Joseph, Mo. This work should be done before the next high-water, and the whole sum asked for should be appropriated at once, both with a view of reducing the cost of materials and also to prevent the whole work from being lost through incompleteness.

ESTIMATE FOR REVETTING 5,000 LINEAR FEET OF BANK.

5,000 cords brush, made into fascine mattresses and placed in position, at $3.50 per cord	$17,500
20,000 yards rock, placed in position, at $3 per yard	60,000
Contingencies	2,500
Total	80,000

I am, general, very respectfully, your obedient servant,

CHAS. R. SUTER,
Major of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

REPORT OF MR. MAX BOEHMER, ASSISTANT ENGINEER.

SAINT LOUIS, MO., *December* 7, 1877.

MAJOR: During the latter part of May, 1877, a survey was made of the Missouri River, in the vicinity of Omaha, Nebr., with a view of ascertaining the proper means for preventing an anticipated cut-off through the Iowa point opposite, or else to devise plans intended to ameliorate the dangerous consequences of such occurrence.

My report on this survey, dated June 27, 1877, intends to establish the impracticability both of prevention and amelioration of the danger, and recommends that no action be taken until after the occurrence of the cut-off, and, further, that time enough be allowed for the river to partly re-establish its normal regimen.

Shortly after, on the 8th of July, 1877, the cut-off happened, and the river broke through the Iowa point with tremendous force.

A resurvey of the ground was ordered, and the field-work commenced on the 23d of October, 1877.

The results of this survey, accompanied by the usual maps, I respectfully submit in the following report:

In breaking through the peninsula, the newly-formed channel, with greatly increased velocity, threw its entire force straight into the Nebraska shore, on a line leading directly toward the Union Pacific Railroad shops. A terrible erosion of the bank at that point was the consequence, and the river had cut into the shore a distance of 1,200 feet when further inroads were checked by extraordinary efforts, under the direction of the Union Pacific Railroad Company. Sand-bags, stone, and brush in large quantities were thrown into the river at the points most severely attacked, and a strong revetment 2,000 feet long constructed. The different data arrived at by the survey show plainly that the river is still in a greatly unsettled condition.

Just below the cut-off, and along the revetment, the river now turns at a radius of only 1,200 feet, and this sharp curve occasions a flat slope of 0.31 foot per mile for some distance above, while farther up the river, and below the bridge, a fall reaching 1.10 to 1.30 feet per mile has been found. The current, as it leaves the sharp bend spoken of, is still swift, entirely beyond its normal velocity, for here the greatest speed found was 5.08 miles per hour at the surface and 4.35 miles at mid-depth. That such current is abnormally swift is proven by the fact that five months previous, during a stage 7 feet higher, the maximum found was 5.85 miles at the surface and 5.23 at mid-depth.

The greatest velocity found during a similar stage of low-water at Saint Joseph, Mo., was but 2.47 miles per hour. Even the slope of the river for a distance of 14 miles was found in a still unsettled condition.

The difference of elevation in the river's surface between Florence and a point three miles below the bridge has decreased but 0.4 foot, although the distance between these points has been reduced by the cut-off from 18 to 14 miles. Before the change in the

river, at a stage 13 feet above low-water, the mean slope between these points was 0.66 foot per mile; at present, at a stage of 6 feet, it is as much as 0.82 foot per mile. It may safely be asserted that the greater part of this increase is still due to the sudden change of the regimen of the river. A discharge taken at a stage of 6 feet gives the following figures:

Average velocity 3.29 feet per second, which equals 2.24 miles per hour; area of cross-section equals 5,007.6 square feet; discharge per second equals 20,178.4 cubic feet.

Concluding, by reason of the above figures, that the river has not recovered its equilibrium and natural shape in the vicinity of the cut-off, a continuation of the violent action during the last high-water may be expected the coming season.

Up to this time the Union Pacific revetments have held the river, and will probably continue to do so, as long as the latter remains in its low stage, even at the very sharp curve of 1,200 feet radius. But it is evident that the high-waters of next June cannot be turned at such an angle, and it must be expected that the river will force an easier curve and freer passage at this point, not through the revetment, perhaps, but either above or below it. The point of impact on the Nebraska shore at present lies a little above the middle of the revetment.

But this will change as the river rises, and it seems highly probable that during the first part of the flood-season the west side of the island created by the cut-off will be cut away farther, and that in consequence the main attack of the channel will be directed against the shore above the riprap. But at the same time, and as long as the flood lasts, the Iowa point, sharp and narrow as the last high-water has left it, will be equally exposed and cut away by the current for some distance. This natural action on the Iowa point will be largely increased in power, not only by the resisting force of the ripraps, but also by the bed-rock beneath and beyond the latter.

Such partial destruction of the Iowa point will not only allow but even compel the river to turn sooner, and at the same time will furnish room for an easier curve. In consequence, the channel will strike the Nebraska shore at a point below the ripraps, and in a line toward the smelting-works. From here the channel will work its way along the Nebraska shore, and remain permanent under the first or second span of the bridge on the west side.

Should this theory prove to be correct, the Union Pacific Railroad shops would remain unharmed. But should the river, as seems possible, work its way behind the revetment from above, and keep on in this direction, the point of impact moving upstream, even then the Union Pacific shops would be safe from destruction by reason of the high elevation of the bed-rock underneath them. The low-water channel can never reach even the extreme eastern parts of the shops, because the bed-rock at this point is but 4.3 feet below low-water.

For the same reason the main thread of the current during the high-water will be held away from this point, since it cannot dig a sufficiently deep channel to create a permanent bed.

Side currents may eventually wash away the earth up to the shops, but against such the banks can be easily held. Only the main channel of the river is to be really feared. At the western edge of the shops, the bed-rock rises to within 1.6 feet of low-water mark, a dip of 2.7 feet in 660 feet.

For the reasons set forth above, I consider the Union Pacific shops exempt from danger, whatever action the river may pursue in its next rise. They surely may be considered safe for one season, and I would therefore recommend that at present only such points be protected as are plainly and clearly in danger, since the river during one year may change in such a manner as to dictate a line of improvement entirely different from that indicated by its present aspect, and work may be wasted at points which the river never will touch.

Only the smelting-works and the western approach of the bridge will, in my opinion, be dangerously exposed to the violent action of the river during the next high-water, because both points lie in the line of attack, and neither is guarded sufficiently by the bed-rock underneath.

At the toe of the western embankment the bed-rock lies 13 feet below the zero of the gauge, and on a straight line from here to a point about 100 feet east of the smelting-works the mean depth of the bed-rock (derived from seven soundings) is 12.8 feet below low-water.

In giving the elevations of bed-rock below low-water, a slope of 0.7 foot per mile has been assumed.

It is probable that one season of high-water will give sufficient time to carry the channel dangerously close to or even beyond these points, and it is therefore necessary to begin the work as soon as possible, and finish it before the height of the June rise inundates the ground.

The protection I would recommend for this purpose consists of two separate revetments, built of stone only, and located as far back toward the bluffs as possible, to take advantage of the higher elevation of the bed-rock, these ripraps to be located as shown on the accompanying sketch. No stone containing less than one cubic foot

should be used in their construction. One of these revetments, 800 feet long, to be built at the west approach of the bridge, the other, 1,200 feet long, close to and in front of the smelting-works, and the faces of both in exact line with each other, and in line with the projecting point of the bluff, about a mile below the bridge.

To build these ripraps back from the shore I would propose to dig trenches with a slope of 1:1 on the inside and 1½:1 on the outside, and fill them with stone, in a manner shown by the sketch below.

The stage of the river up to the end of April would allow a depth of 10 feet for these trenches, and make it possible to draw off the water by means of ditching. It is expected that the river will work to these ripraps, and, by undermining, cause the stone to tumble in and take its own slope; there is stone enough to form a riprap 3 feet thick, and reaching down to bed-rock at a slope of 1:1. Some repairs and additional stone may be necessary in places hereafter, but in the main these ripraps would, I believe, be largely sufficient to hold the bank.

The cost of this work is estimated as follows:

3,000 linear feet riprap, at 4.33 cubic yard	12,990 cubic yards stone.
Subtract 25 per cent. for solid-rock measure	3,247 cubic yards stone.
Total	9,743 cubic yards stone.

For the following estimate of earth-excavation 1,000 linear feet of trench is allowed for ditching.

4,000 linear feet of trench, at 4.63 cubic yard	18,520 cubic yards earth.

COST.

9,743 cubic yards solid rock (placed), at $3.50	$34,100 50
18,520 cubic yards earth-excavation, at 20 cents	3,704 00
	37,804 50
Contingencies	3,795 50
Total cost	41,600 00

According to your instructions, the survey was extended farther on the other side of the river, so as to gather all available information and investigate the apprehended danger to the city of Council Bluffs, Iowa. Additional lines were run for that purpose, especially to establish the location of the lake and the line of bluffs above that town. The result shows no immediate danger from any direction whatever.

Quite a large part of Council Bluffs is built on the Missouri River bottom, and is for that reason alone to be considered as standing on dangerous ground, since the river is liable, in its continual changes, to strike any point between the bluffs; but that there is no special or immediate danger to any part of that town at the present time is proven by the following facts and figures, viz:

The bluffs above the city protect it to a large extent; the nearest point of the river-bed is still 9,500 feet distant from the Chicago and Northwestern depot on Broadway; the apex of the bend below town is 15,800 feet distant from the same point; and the peninsula, at its narrowest point, is still 23,000 feet, or a little less than 4½ miles, wide.

The river may hereafter possibly, and even probably, work its way into its old bed, the present lake; but even this would not endanger the city, but, on the contrary, would create a more desirable landing, and still leave the river-bed a distance of 7,500 feet from the Northwestern depot.

In addition to all this, the recent formation of the cut-off will draw off the water from above faster, and thereby give the river a tendency to straighten out in that locality. This will lessen the danger of severe encroachments for some years to come, especially since the flood-level has also been lowered by the same agency.

Very respectfully,

MAX BOEHMER,
Assistant Engineer.

Maj. CHARLES R. SUTER,
Corps of Engineers, U. S. A.

SURVEY OF MISSOURI RIVER AT ATCHISON, KANSAS.

UNITED STATES ENGINEER OFFICE,
Saint Louis, Mo., January 3, 1878.

GENERAL: I have the honor to submit herewith a report and map of a survey made of the Missouri River, near Atchison, Kans., by my

assistant, Mr. Max Boehmer, in compliance with your instructions of May 18, 1877. From this report it will be seen that there are impending changes in the channel of the river at this point which threaten to destroy the railroad-bridge, or to render its draw-spans impassable for steamboats.

Three sources of danger are noticed: First, it appears that in the bottom-land on the Missouri side of the river there exists a chain of lakes, which are quite probably the remains of ancient channels of the river. Much apprehension is felt that, owing to ice-gorges or other causes, the river might break through into these lakes and abandon its present channel altogether. This contingency, although not impossible, I regard as highly improbable, for although there are thousands of instances of similar lakes scattered through the bottom-lands of the Missouri, Mississippi, and Arkansas Rivers, yet no instance has yet been recorded, to my knowledge, of a change occurring of the character apprehended here.

The second source of danger lies above Atchison, where a narrow neck separates two bends of the river. There is considerable abrasion on the upper side of this neck, and it is possible that a cut-off may eventually form here. Still, the danger is not very great, as the lower side of the neck is not much affected and the point of impact is working down stream. It would be desirable, however, to extend the survey several miles farther, and to watch and note any further changes in this neighborhood.

The immediate source of danger lies, however, in the rapid caving of the Missouri shore in the bend immediately above the bridge. This has already, since the completion of the bridge, progressed to an extent that seriously threatens both the structure itself and the maintenance of navigation through the draw-spans.

It seems, therefore, imperatively necessary to protect this bank from further attack as soon as possible, as any delay will probably entail the construction of additional works designed to force the channel farther to the north and west.

Mr. Boehmer recommends that about 7,000 feet of bank be protected by a revetment of mattresses loaded with stone, and submits an estimate therefor of $56,000. The character of the work would be similar to that carried on during the past season at Saint Joseph, Mo., and which has proved satisfactory. The plan and estimate are approved by me, and I would merely add that if the work be undertaken, the whole sum should be appropriated at once, as there is great danger that the work, if incompletely carried out, may be entirely lost.

I am, general, very respectfully, your obedient servant,

CHARLES R. SUTER,
Major of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

REPORT OF MR. MAX BOEHMER, ASSISTANT ENGINEER.

SAINT LOUIS, MO., *December* 28, 1877.

MAJOR: I have the honor to submit the following report on the survey of the Mississippi River in the vicinity of Atchison, Kans.

The field-work was done during the first part of November, 1877, and takes in a distance of 12 miles by channel from a point 3 miles below the bridge to the apex of the bend above Doniphan, Kans.

The stage of the river at the time was recorded as 4 feet 6 inches above low-water mark on the bridge-gauge at Saint Joseph, Mo. The zero of this gauge would be more

correct if assumed 2 feet lower. This would make the actual stage during the survey 6 feet 6 inches above the lowest water, or 15 feet 6 inches below the high water of 1844.

The slope of the river near Atchison, measured at short distances, shows considerable irregularity, ranging from 0.48 to 0.90 foot per mile. But comparing the slopes of longer stretches, from 3 to 5 miles in length, more uniformity is found, *i. e.*, from 0.60 to 0.76 foot per mile, while the mean slope of the entire distance surveyed was found to be 0.70 per mile.

There is no immediate danger on hand from any quarter in this locality, nor is such apprehended by corporations of individuals interested; but there is good cause for apprehension in the near future from two different and distinct directions. A third danger, also, is pointed out in the possibility of a sudden or gradual entrance of the river into the chain of lakes, running in a southerly direction and on a line from 2 to 3 miles east of the bridge. Such occurrence, however, I consider as impossible, judging from the character and the condition of the ground, and it could be brought about only by a succession of preliminary changes which, by reason of their nature and extent, would alter the relative conditions so radically as to present a case of entirely different aspect. The great volume of water will take the way of least obstruction, and the nature of the ground at present justifies the assertion that the heaviest ice-gorge in the bed of the river would appear insignificant as an obstruction compared to the natural impediments prohibiting the formation of a channel through the chain of lakes. The stretch of high ground, 4,200 feet wide, separating the upper lake from Sugar Lake, presents an obstruction far more formidable than any that could possibly form in the bed of the river at either its high or low stage.

But there is danger in store for the bridge from the continual abrasion of the Missouri shore directly above it, and also from the possible formation of a cut-off through the neck of land opposite Doniphan. Should the river break through here, it would be impossible to foretell the consequences, and entirely impracticable (by reason of the enormous cost) to guide the water safely past the bridge. Such radical change in the river may occur possibly without harming the bridge to any great extent; but it is far more probable that, in breaking through and striking the Kansas shore, the river will rebound, strike the east end of the bridge, and establish its main channel, at least for a time, under one of the fast spans, making the structure at once a total impediment to navigation. And should the channel work its way under either of the two most eastern spans, it will in all probability result in the destruction of both, since neither the most eastern pier nor the east abutment have their foundation on the bed-rock underneath. This may not be a necessary consequence under ordinary circumstances and at a normal condition of the river, but it is almost sure to happen under the heavily-increased pressure consequent upon the formation of a cut-off only 3 miles above. The only safety, therefore, lies in the prevention of the cut-off.

The width of the neck under question is still 5,300 feet at the narrowest point; the ground is high and old, and covered with heavy timber, and there is but little cause for apprehension for some years to come, especially since the lower side of the neck is safe from further encroachment, because here the river is held in check by the bluffs on the Kansas side above. But the upper side, from the peculiar shape of the river at that point, is in a position to be attacked severely; and such attack is apt to increase in power the farther the river eats into the shore, because such action will tend to decrease in proportion the radii of the reversed curve which the channel assumes from here to the bluffs below. The upper side of the neck, therefore, alone needs protection, and to ascertain the proper method a further survey, reaching 8 miles above the present, is necessary.

The second danger to the bridge has its source in the caving of the Missouri bank in the bend above the bridge. This, if allowed to continue, may cause the channel to leave its position under the draw, and at last even endanger the safety of the eastern end of the bridge. The river has been suffered to cut into the bank too far already at this point, and it would be preferable in a contemplated improvement to re-establish the shore-line of 1873 by means of a dike built of mattresses. But the greater cost of such improvement would hardly be justifiable, since the present shore-line leads the channel directly under the draw, over 90 per cent. of the water in the river passing under it at a channel-depth of 53 feet.

By reference to the map, it will be seen that since 1873 the banks of the bend have been cut away more or less, and to a maximum of 800 feet, with the exception of a stretch 3,400 feet long, which has been left intact, and remains exactly the same as it was four years ago. This strip is situated just below the old river-bed, and the cause of its preservation may be found partly in the peculiar shape of the bend, as the drawing will show, and partly in the stronger resistance of the material deposited in the old river-bed. This material consists of fine sediment and vegetable matter entirely, without any mixture of coarse sand. I think it, therefore, sufficient at present to protect the shore up to this point, a distance of 7,000 feet. Hereafter the continued cutting above will probably necessitate a further revetment above; but the longer this

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may be avoided, the less revetment will eventually be required, since the point of impact at the head of this bend is moving downstream, and will continue to do so as fast as the Kansas shore below Independence Creek is washed away.

The importance of the Atchison bridge, because of the heavy traffic over it, strengthens the argument that steps should be taken as soon as possible to assure its safety; and the interest of the free navigation of the river demands that efficient measures be employed to secure the permanency of the channel in its present position, under the draw-span of the bridge.

For the protection of the bend above the bridge, I would recommend a simple revetment of mattress-work, loaded with stone and built to a height of 6 feet above low-water; the entire work to be 7,000 feet long and 40 feet wide.

Assuming the price of stone delivered at $2 per cubic yard, and brush delivered at $1.25 per cord, the cost of the work, with contingencies, is estimated at $8 per linear foot, making the cost of the entire work $8 \times 7{,}000 = \$56{,}000$.

Very respectfully,

MAX BOEHMER,
Assistant Engineer.

Maj. CHARLES R. SUTER,
Corps of Engineers, U. S. A.

EXAMINATION OF MISSOURI RIVER AT PLATTSMOUTH, NEBRASKA.

UNITED STATES ENGINEER OFFICE,
Saint Louis, Mo., February 9, 1878.

GENERAL: I have the honor to forward herewith the report of an examination made at Plattsmouth, Nebr., by Mr. A. H. Blaisdell, assistant engineer. From this report it will be seen that the regimen of the Missouri River, in this neighborhood, owing to the influx of Platte River, is exceedingly unstable, and that the erosion of the banks threatens the destruction of much valuable farming-land and seriously endangers the railroads running to this point.

The extent of damage threatened as well as the cost of protection cannot be given without a regular survey, which should cover the whole ground between Plattsmouth and Omaha, in order to give a clear idea of the subject. The total length of survey required would be 30 miles, and the cost would be $3,500, which it is recommended should be appropriated for the purpose.

I am, general, very respectfully, your obedient servant,

CHAS. R. SUTER,
Major of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, United States Army.

REPORT OF MR. A. H. BLAISDELL, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Saint Louis, Mo., January 15, 1878.

MAJOR: The following report is the result of my recent examination of the Missouri River, at Plattsmonth, Nebr.:

In the vicinity of Plattsmouth, the channel and bars of the Missouri River are subject to more radical changes than they are at almost any other portion of its course. The Platte River, which here enters the larger stream, has its greatest flood, from 3 to 5 feet, usually in April, while that of the Missouri occurs generally in June.

In consequence of this non-conformity, the point of junction of the two rivers differs quite widely in different years, and even in the same year; the Platte, in freshet, sweeps its way through the sand-bars deposited by the Missouri during its high water, and again has its mouth changed when the larger stream is in flood.

A small sketch of the vicinity, made during my examination in December, accompanies this report.

On the Plattsmouth side the river has worn away the banks where ten years ago was a considerable bottom up to the toe of the bluffs, while on the Iowa side the two rivers, acting conjointly, have for a long time been, and are now, making deep inroads into the rich farming alluvial lands.

Plattsmouth is the eastern terminus of the Burlington and Missouri River Railroad in Nebraska, between which and the Iowa division of the Chicago, Burlington and Quincy Railroad a large and increasing transfer-business is maintained.

In order to preserve an already restricted depot and yard grounds, the Burlington and Missouri River Railroad Company was obliged to protect the Nebraska bank, and this they have quite successfully accomplished by a stone revetment extending for over a mile from the end of their track northward. With the exception of a few slides, this revetment has stood well, most of it probably reaching to bed-rock, which outcrops in places in the bank.

On the Iowa side, however, the problem was more difficult; the rock is here about 80 feet below the level of the bank, along which the channel generally ran with a velocity of from 4 to 5 miles per hour. The transfer-landing had to be constantly changed, involving such expense that the Chicago, Burlington and Quincy Company resolved to build a landing which should be permanent. This resolution resulted in building a dike 850 feet long, inclining at an angle of about 45° with the perpendicular to the former channel, at the end of which, in low water, the transfer-boats have their landings.

The manner of constructing this dike was quite novel. Piles in two rows were driven at 12-foot distances, and spanned successively by girders, on which rails were laid, and stone and brush thrown from cars brought on them; cleats nailed to the piles served as a temporary rest for the brush foundation, and stone was thrown on until the cleats broke, and the foundation, guided by the piles, sank to place. The dike cost about $28,000. A large deposit of sand took place below the dike, while above it the former channel has been nearly, if not quite, closed.

The dike has very materially narrowed the water-way, its former width of 1,200 feet having been decreased to 700 feet, and in high stages the water, of course, runs over it, but it has withstood successfully two break-ups of the ice, and, with the careful watching and repairs it received from the railroad company, there is no reason it should not last indefinitely.

On the Iowa side the bank immediately on the river is on a higher level than it is in the interior, and is, besides, cut up by sloughs. In times of floods the water finds its way into the farming-lands of the bottom, and its path is marked by a denuding of the land of all vegetation, except such trees as can withstand the force of the current.

It is apprehended by some of the residents that, when the river cuts beyond the limits of the present high bank, at a stage a good deal lower than when it occurs now, the river will overflow the interior country. A small community of farmers, combining together, have built a levee some three miles long, shown on the sketch, for their own protection. This levee has done good service, but with the present rate of cutting, a few years will carry the river into it.

The neck of land between Pacific and Saint Mary's Bends is gradually becoming narrower, and a cut-off is imminent if the cutting continue, as there is no doubt it will.

In consequence of the cut-off at Omaha, which occurred in July last, the caving of the banks will be more rapid, and will hasten the cut-off at Plattsmouth, which, if allowed to occur, would be disastrous in the extreme to the railroad companies and farmers below its location. Should, however, the cut-off be prevented from taking place, unless the upper side of the "point" be also protected, Plattsmouth would in time lose its river-frontage from the gradual recession of the bends and their accompanying bars down stream.

The river interests of Plattsmouth, outside of the railroad transfer, are small at present. A wagon-ferry, as shown on the sketch, is maintained, and crosses a large emigration to the Platte Valley.

In the absence of an instrumental survey, it is difficult to say what should be done in the way of improvement, and it is recommended that such a survey be made. The shortest permissible survey would be about 25 miles long, and should cover quite thoroughly the bottom-land on the Iowa side of the river; but as Plattsmouth is only about 28 miles below Omaha, and as the river between these points has a very important bearing on any work of improvement, it is recommended that the survey should connect with the one recently made at Omaha.

The linear distance of the required survey is about 30 miles, and would cost $3,500.

Very respectfully, your obedient servant,

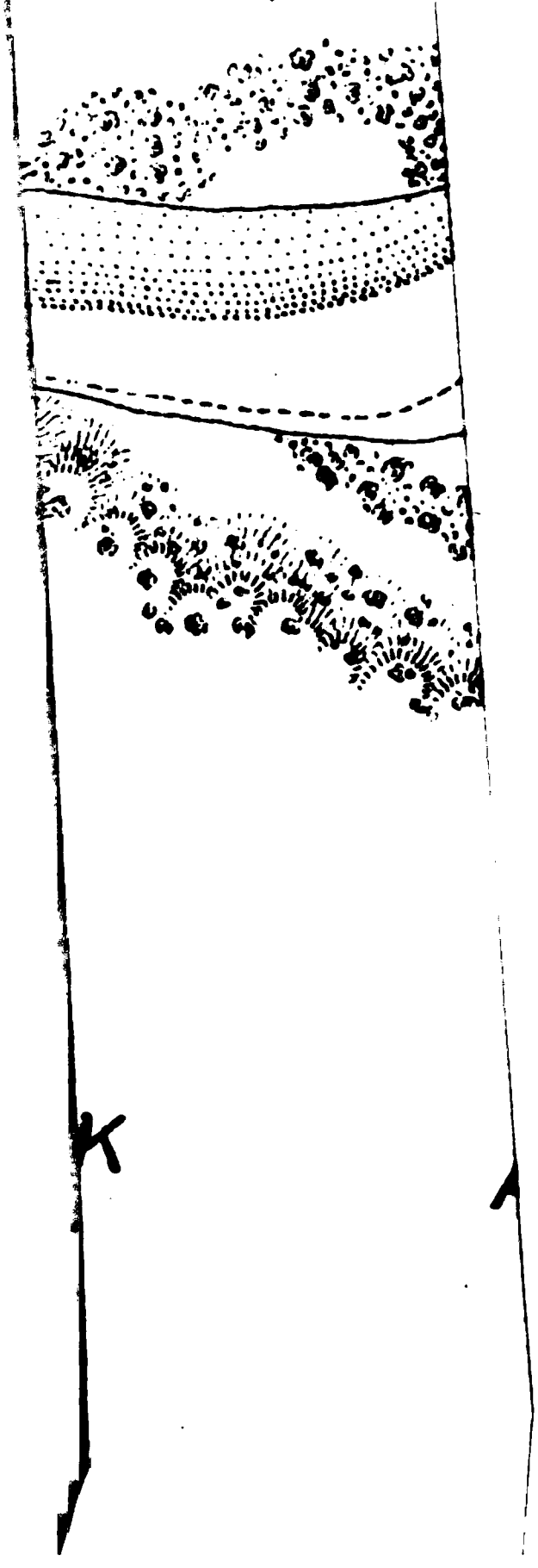
A. H. BLAISDELL,
Assistant Engineer.

Maj. CHARLES R. SUTER,
Corps of Engineers, U. S. A.

Scale 1 Inch to 1 Mile

U

A



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EXAMINATION OF MISSOURI RIVER AT BROWNVILLE, NEBRASKA.

UNITED STATES ENGINEER OFFICE,
Saint Louis, Mo., February 9, 1878.

GENERAL: I have the honor to transmit herewith a report of an examination made at Brownville, Nebr., by Mr. A. H. Blaisdell, assistant engineer. From this report it will be seen that Brownville is situated at the foot of a sharp bend of the Missouri River, and the erosion of the shore on the Missouri side is causing a recession of the bend down stream, thereby threatening the filling up of the harbor. At the same time the cutting of the Nebraska shore, in front of and below the town, is causing the destruction of much valuable property. It is probable that the only way to check these changes will be to directly protect the caving banks.

The actual extent of such work needed cannot be decided until a regular survey is made, though from present appearances Mr. Blaisdell estimates the cost at $50,000. A survey to determine this point will cost $1,600 as a minimum, but to satisfactorily study the problem it would be advisable to extend the survey so as join the one already made at Nebraska City. The distance to be surveyed in this case would be 23 miles, and the cost would be $3,000, which it is recommended should be appropriated for the purpose.

I am, general, very respectfully, your obedient servant,

CHAS. R. SUTER,
Major of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

REPORT OF MR. A. H. BLAISDELL, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Saint Louis, January 15, 1878.

MAJOR: I have the honor to present herewith a report of my recent examination of the Missouri River in the vicinity of Brownville, Nebr., with an accompanying sketch on a scale of one inch to the mile.

In the vicinity of Brownville, Nebr., the bluffs of the Missouri Valley lie about twelve miles apart. In Nebraska they are washed by the river or lie within short distance of it, and in Missouri the intervening alluvial bottom supports a well-settled farming community.

The soft alluvium of the Missouri side yields readily to the action of the current, and the results are the same as elsewhere in its course, frequent shiftings of the river-channel and a gradual movement of the bends down stream.

Brownville is one of the oldest towns of Nebraska, and has tributary to it an unusually well-developed and productive country. It is the nominal terminus of the Nebraska Railway, better known under its former name, Midland Pacific, which runs westward from Nebraska City. A railroad along the river-bank connects the two cities.

The greatest amount of caving of the banks has occurred within the past three years, during which time about 300 feet has been washed away at the foot of the main business street of Brownville. The railroad company has been compelled to move its depot-grounds, buildings, and road-bed, until now the track for nearly a mile northward lies close against the high bluffs, and the protection of the bank has become a necessity which can no longer be delayed.

A portion of the town is built on the bottom below Main street, and the encroachment of the river has compelled the removal of a number of the residences, but there still remain about twenty-five houses, a portion of which, as well as a fertile farming district below, is in danger, if the banks are allowed to continue cutting.

The greatest amount of caving occurs, however, on the Missouri side, in the bend opposite the city, and the "point" is fast moving down in front of the town. When this occurs the present situation at Nebraska City will be duplicated, the river-frontage of Brownville being entirely occupied by sand-bars. The inhabitants naturally desire

to protect their landing, their transfer business being large and increasing. A survey would, in all probability, develop no other plan of improvement than a revetment of the caving bank, and it is very important if any such improvement is to be made that it be undertaken at once.

It is therefore recommended that a sum of money be appropriated which would allow works of protection to be prosecuted at the same time that a survey would be in progress, and to leave the final estimate of such work until the survey determines it.

At the very least, over a mile of bank must be protected, a preliminary estimate of cost of which is placed at $50,000.

The shortest permissible length of survey required is 16 miles, between Peru, Nebr., and Nemaha City, Nebr., which would cost $1,600; but it would be far preferable if we could connect with the survey already made at Nebraska City. This would increase the survey distance to 23 miles, and would cost $3,000.

Very respectfully, your obedient servant,

A. H. BLAISDELL,
Assistant Engineer.

Maj. CHAS. R. SUTER,
Corps of Engineers, U. S. A.

M 12.

SURVEY OF MISSOURI RIVER AT SIOUX CITY, IOWA.

UNITED STATES ENGINEER OFFICE,
Saint Louis, Mo., May 23, 1878.

GENERAL: I have the honor to report that in accordance with your instructions of April 24, 1878, I have caused an examination and survey to be made of the harbor of Sioux City, Iowa, and the report of Mr. Max Boehmer, assistant engineer, together with a map of the locality, is submitted herewith. The expenses of this examination were defrayed by the city government. Lack of time and funds prevented the extension of the survey to the full extent deemed desirable, and the stage of water was too low to obtain definite information respecting the direction of currents, &c. Still, I think Mr. Boehmer's report presents the case fairly. He states that, owing to several cut-offs which have occurred above the town, the regimen of the river has been very much disturbed, producing an excessive slope and velocity, besides directing the current against the town landing, which has been severely abraded. He states that changes which are still in progress render it probable that after the next high water, the point of impact of the current will be transferred so far downstream that the upper portion at least of the landing will probably be safe. To protect the whole front will require a revetment 3,000 feet long, extending from Perry Creek to Jennings street. Below that point the value of property would not justify the expense of works of protection.

With these conclusions I agree substantially, as also with the kind of protection recommended, but I should not feel justified in recommending as extensive a revetment as mentioned until I have had an opportunity of seeing the condition of affairs at high water. As the case stands, it seems to me that the caving of the point of the Nebraska shore above Covington threatens to fill up the upper portion of the harbor with sandbars, and that this danger is more imminent and more to be deprecated than the caving in of the opposite shore. The preservation of the harbor will probably require, therefore, that this point should be held, and, therefore, the work along the town front should, for the present, be limited to that portion which would need protection under any circumstances.

For the present, therefore, I should recommend that only 1,500 feet of revetment be built from Jennings street upstream, which would, on Mr. Boehmer's estimate, cost $12,750, to which should be added $2,250 for further surveys, bringing the whole amount up to $15,000, which should be made available at once,

I am, general, very respectfully, your obedient servant,

CHAS. R. SUTER,
Major of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

REPORT OF MR. MAX BOEHMER, ASSISTANT ENGINEER.

SAINT LOUIS, MO., *May* 20, 1878.

MAJOR: I have the honor to report as follows on the survey of the Missouri River in the vicinity of Sioux City, Iowa.

The field-work was done during the first week of this month.

The survey is intended to determine the cheapest and most feasible plan for the protection against the encroachment of the river of the Iowa bank immediately in front of the town.

The accompanying map shows that the river-frontage, from the point of bluff above Perry Creek to the Floyd River, has, since 1870, receded a distance of from 100 feet to a maximum of 300 feet. The heaviest inroads have been made since 1876, after the Missouri cut its way into the bed of the Big Sioux River, at a point 2¼ miles above town.

By this change the river shortened its course about one mile, and the increased speed of the current as well as the new direction of the channel caused a greater rate of abrasion in front of the town. The stream has not yet recovered its normal slope at this point, I think, judging from the great velocity of the current at different places. But this is due, probably, less to the Big Sioux cut-off, but is caused to a greater extent by another cut-off which occurred but a year ago, and which shortened the river 4 miles at a point about 12 miles above town.

The levels show a mean slope of 0.923 foot per mile for a distance of 6 miles, the extent of the survey. The range between high and low water at Sioux City is 15.5 feet, according to records in the city engineer's office. The stage of the river during the survey was 10.1 feet below an approximate highwater mark of 1857, the highest water known.

The river above town has no well-determined shape, the shores are irregular and unstable at most points, and changes are liable to occur here, which would greatly affect the course of the channel along the town front. Revetment of the Iowa bank is the only remedy, but till the action of the next high water has been observed, it is hardly possible to form a conclusive opinion and determine the length of revetment which is absolutely necessary.

The shore from the bluff to Perry Creek is protected from serious attack by the bluff itself, and may safely be left without revetment under all circumstances. From Perry Creek to Nebraska street the bank will probably be attacked to some extent, but not seriously. But at the latter street the channel strikes the shore, and from here to the mouth of Floyd River heavy caving must be expected for this season and probably the next. By that time it is reasonable to expect such changes in the river as will make all revetment of the upper portion of the shore-line unnecessary, for the following reasons: The lower part of the northern side of the willow island and also the point of the Nebraska shore at Covington are attacked by the full force of the channel, and both are caving fast; from here the channel crosses to the Iowa side. The point of impact on the latter shore will move downstream as fast as the Nebraska shore and the island are washed away, and one attack of high water may have sufficient force to carry the point of impact below the river-frontage of the city proper. The shore below Jennings street is of less importance and not worth protecting.

It is also necessary to observe the effect of a high stage of water in the old bed of the river, the present slough, south of the willow island. The water in this slough has no tangible effect on the main channel during a low stage, and, at the time of the survey, its sectional area showed but 14.3 per cent. of the total section of the river; this representing about 10 per cent. of the total discharge. But its effect during a high stage is probably greater and will develop a tendency to drive the main channel over to the Iowa side. I have been informed, however, that every year this old chan-

nel grows more shallow, and from such action it may be supposed to have but little effect even during a high stage.

The following conclusions may consequently be drawn:

1st. There is no imminent danger to any valuable buildings or improvements at any point.

2d. The cost of revetment exceeds the amount of damage that can possibly be done to real estate and buildings.

3d. The river-frontage of the main portion of the town may be expected to be perfectly safe after the season of 1879.

4th. The length of revetment necessary cannot be safely determined until the effect of the next rise has been observed.

5th. No revetment is necessary above Perry Creek.

Should it, however, be deemed desirable to preserve the river-frontage in its present shape at all hazards, then a mattress revetment, 3,000 feet in length and reaching from Perry Creek to Jennings street, is to be recommended. Stone in this neighborhood cannot be furnished for less than $3.25 per cubic yard, but even at that price it is cheaper and more safe to use stone than to adopt a system of piling, or any other method of holding the mattresses in place.

With the above price for stone, and brush at $1 per cord, the cost of revetment has been estimated at $8.50 per linear foot, making a total cost of 3,000 feet at $8.50, $25,500.

Very respectfully,

MAX BOEHMER,
Assistant Engineer.

Maj. CHARLES R. SUTER,
Corps of Engineers, U. S. A.

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APPENDIX N.

ANNUAL REPORT OF COLONEL J. H. SIMPSON, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1878.

UNITED STATES ENGINEER OFFICE,
Saint Louis, Mo., July 16, 1878.

GENERAL: I have the honor to submit herewith my annual report upon the river and harbor improvements under my charge, for the fiscal year ending June 30, 1878.

Additional duties have been performed by me during the year as follows:

President of Board of Engineers constituted by Special Orders No. 141, Headquarters of the Army, Adjutant-General's Office, dated June 28, 1877, to examine and report upon the most advisable means of preserving the water-front of Vicksburg, and of arresting the danger which appears to be apprehended from the cut-off opposite that city. Report of Board submitted under date of January 22, 1878.

President of Board of Engineers constituted by Special Orders No. 88, Headquarters Corps of Engineers, dated August 1, 1877, to consider and report upon the project for a bridge across the Ohio River at Beaver, Pa. Report submitted August 15, 1877.

President of Board of Survey constituted by Special Orders No. 41, Headquarters of the Army, Adjutant-General's Office, dated February 26, 1878, to examine and report fully upon the facts connected with the loss of the dredge-boat McAlester. Report submitted from New Orleans, March 23, 1878.

President of Board of Engineers constituted by Special Orders No. 40, Headquarters Corps of Engineers, dated April 9, 1878, to consider and report upon the plan and location of the bridge proposed to be erected over the Missouri River at or near Glasgow, under an act of Congress approved March 13, 1878. Report submitted April 20, 1878.

Very respectfully, your obedient servant,

J. H. SIMPSON,
Colonel of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

N 1.

IMPROVEMENT OF THE MISSISSIPPI RIVER BETWEEN THE MOUTHS OF THE ILLINOIS AND OHIO RIVERS.

BETWEEN THE ILLINOIS AND MISSOURI RIVERS.

The balance of appropriation applicable to work within these limits July 1, 1877, was $10,561.72, with which it was proposed to continue the

construction of the dam at Piasa Island, and to make such repairs and extension of the shore connections of Alton Dam as were needed.

DAM AT PIASA ISLAND.

By the operations of the year the prism of the dam has been filled to a height of 6 feet above low water, except for a distance of 400 feet near its eastern end, which remains incomplete. The head of the island has also been revetted to prevent its further erosion. Both dam and revetment are now practically complete, at a cost of $32,333.30, against an estimated cost of $41,210.73; the saving arising from the unexpected stability of a sand-bar, which is crossed by the dam and which has not washed away as anticipated.

The expenditures were—

22 piles	$66 00
5,857.03 cubic yards riprap	7,463 45
Grading	168 49
Engineering and contingencies	898 99
	8,596 93

ALTON DAM.

The revetments have been repaired and extended to an extent deemed sufficient to secure the work.

The expenditures were—

998.37 cubic yards riprap	$1,185 60
Grading	27 07
Engineering and contingencies	346 40
	1,559 07

The completion of these dams renders it proper to commence a new work under the recent appropriation of $20,000, the location of which will be made when the stage of water permits.

SAWYER BEND.

The work at this locality having been suspended since 1875 for want of funds, the upper end of the protection was in danger of being detached from the shore, rendering it necessary to revet in part the space between the two upper spur-dikes, and also to repair a number of the spurs.

The expenditures were—

1,192.62 cubic yards riprap	$1,514 80
Engineering and contingencies	360 10
	1,874 90

Further repairs will be necessary during the coming season, and it is proposed also to devote a part of the appropriation of June 18, 1878, to the prolongation of the protection.

VENICE.

No work was done at this locality except a survey to ascertain the damages, if any, resulting to riparian owners from the government work actual and proposed. The report of this survey was made April 10, 1878.

No work is proposed the coming season.

CAHOKIA CHUTE.

The balance available was not sufficient to warrant any attempt at the construction of the dam. The revetments at the site of the proposed dam were strengthened and the revetment of the west side of the island completed for a length of 685 feet.

The expenditures were—

4,093.47 cubic yards riprap	$4,574 75
Grading	332 05
Engineering and contingencies	537 85
	5,444 65

In consequence probably of the suggestion made in my last annual report that this chute would afford a favorable opportunity for the construction of an ice-harbor, a special report and estimate was called for, which was made in my absence by Capt. Charles J. Allen, Corps of Engineers. The plan proposed I deem practicable, and the object is certainly an important one. I therefore recommend the matter to the consideration of Congress.

In the appropriation act approved June 18, 1878, provision was made for the construction of the dam across the chute to the full amount of the estimate. It is hoped this will suffice to complete the low dam, and any further estimate or appropriation would be applicable to the construction of the ice-harbor. The two channels at Arsenal Island have continued to divide the water, either being navigable, but the larger and deeper boats have mostly used the Cahokia Chute.

A recent examination of the site of the dam develops a regular bottom with comparatively slight variations of depth, except along the Illinois shore, where the depth at a 22-foot stage was 37 feet. This, however, is in a blind pocket behind a sand-bar, the greatest depth in the true channel being 24.8 feet. The conditions are favorable to the construction of the dam if no serious change takes place when the river falls.

As an illustration of the influence the change of the bottom has upon the navigation of the Mississippi and all questions of its improvement, the following comparison of cross-sections is made:

First section made December, 1874.

Area of Cahokia Chute sounded at 6-foot stage:			
Reduced to 8-foot stage	=12,411	and to 0 stage	= 6,526
Area of Arsenal Chute sounded at 6-foot stage:			
Reduced to 8-foot stage	=19,775	and to 0 stage	= 8,023
Total area, square feet	32,186		14,549

Second section made November 25, 1876.

Area of Cahokia Chute sounded at 10½-foot stage:			
Reduced to 8-foot stage	=20,700	and to 0 stage	=11,332
Area of Arsenal Chute sounded at 10½-foot stage:			
Reduced to 8-foot stage	=16,800	and to 0 stage	= 4,078
Total area, square feet	37,500		15,410

Third section made July, 1878.

Area of Cahokia Chute sounded at 22-foot stage:			
Reduced to 8-foot stage	=16,036	and to 0 stage	=4,598
Area of Arsenal Chute sounded at 22 foot stage:			
Reduced to 8-foot stage	=12,300	and to 0 stage	=3,875
Total area, square feet	28,336		8,473

Of the 4,598 square feet found at Cahokia Chute after reducing to 0 stage, 3,112 square feet are cut off from the main river, leaving 1,476 square feet to be added to 3,875 to give the low-water area of 5,351 square feet obtained by reducing the soundings taken at 22-foot stage. Comparing this with areas obtained by reduction from soundings at lower stages, the fact of enlargement of section attending fall of surface is evident, and affords another link in the chain of evidence that the channel-filling at high water is general and not limited to bars or shoals.

HORSETAIL BAR.

The difficulties encountered at this locality in previous years were not repeated the past season. For a time the depth in the channel was reduced to 4½ feet, and much apprehension was felt on the part of river-men that the previous experience would be repeated. As there was a disturbing cause at work producing a local movement of sand, the hope was indulged that the obstruction would be but temporary. This hope was realized in a few days, a continual decline of stage brought the scattered waters together, and a fair channel was maintained for the balance of the season, at no time affording less water than existed elsewhere in the river, and gradually deepening to 8½ and 9 feet, at which depth the channel maintained itself during the winter, by which I mean that during the minor rises and falls of the late fall and winter the channel maintained a nearly constant depth.

It has been repeatedly said in the reports upon these works that the improvement of the low-water river would not secure a good channel at all stages. It is still necessary to repeat the statement, for it is a fundamental proposition consequent upon the fact that the bed of the river fills at flood and clears itself at low stages. Failure to recognize this fact with its logical consequences must always lead to failure and disappointment in practical works, and vitiate all theoretic reasoning about the river. The period of worst navigation last year was during the time of decline from a stage of 10 to 7 feet; previous years it was at a higher stage. The cause of last year's trouble arose from the peculiar course of the channel around the head of one of the dikes, the outer end of which had settled during the summer rise. A sand-bar was deposited in mid-river above and quite near the dike. When the water fell the channel lay between the end of the dike and this bar. Under these conditions, when the dike was restored, the end having settled some 28 feet, the channel was crowded against the bar, which yielded (but only after the depth of water became over 70 feet). This scouring of the bed and erosion of the bar set in motion a volume of sand which exceeded the ability of the current in the section of river below to dispose of, and, of consequence, a reef was developed. The spill-way over this reef being three-fourths of a mile or more in length, allowed the water to pass in a thin sheet without any defined channel. Early in October the dike was restored to its full length, and so soon as its reconstruction ceased the cutting at the dike stopped, the reef was cut through, and a defined channel, permanent for the season, was developed.

The training-wall mentioned in my last annual report as necessary to complete the improvement was commenced last season, and 2,550 feet of it built to a height of 12 feet above low water, at a cost of $8 per linear foot.

The only work on the perpendicular dikes during the year was the restoration of the outer end of dike No. 3, and the closure of one of the breaches in dike No. 5.

The expenditures were—

Dike No. 3:	
10,256.20 cubic yards riprap	$10,842 49
Engineering and contingencies	784 43
	11,626 92
Dike No. 5:	
4,290.57 cubic yards riprap	$4,415 82
Engineering and contingencies	258 30
	4,674 12
Training-wall:	
357 piles	$1,129 69
976.34 cords brush	1,686 36
Old barge-hull	350 00
15,346.09 cubic yards riprap	16,246 72
Engineering and contingencies	985 39
	20,398 16

During the coming season it is proposed to close the remaining breach in dike No. 5; to repair dike No. 3, and to continue the construction of the training-wall.

FORT CHARTRES DAM.

No work was done at this dam during the year, and none is contemplated during the coming season. Continued changes in the bend above may eventually bring about the necessity of allowing the channel to go through the dam, but it is hoped that an appropriation may be made applicable to the protection of Fish Bend in time to prevent this change. This bend is caving rapidly and needs protection. The length is very considerable—20,000 feet—and its protection will cost about $10 per foot.

TURKEY ISLAND DAM.

Remains as last reported; no work done or contemplated.

PROTECTION OF BANK NEAR KASKASKIA.

After long hesitation the attempt was made to check the caving of this bend. Brush and stone footing was placed along 1,100 feet of the bank near the head of the active caving, and with a view to guard against a possible cutting of the Mississippi through into the Kaskaskia immediately above the point of nearest approach of the two rivers. The severe weather of the latter part of November rendered it necessary to close operations when the height of the protection was 13 feet above low water. The small balance available did not warrant resumption of work.

The spring rise of the river commenced an active erosion about one-half mile above the revetment, which in a short time worked down to it and to some unknown extent behind it. The high stage of water when the locality was last visited was unfavorable to an accurate determination of the condition of the work placed last fall; but there are serious grounds to apprehend that it is nearly if not wholly lost. Had the amount available been greater so that the work could have been resumed early this spring, the loss would not have occurred.

The changes at this locality during the winter and spring have been very great, the caving progressing more rapidly than ever before, ren-

dering it probable that the portion of river between Kaskaskia and Saint Mary's will be very troublesome to navigation the coming fall from the vast quantities of sand which have been moved out of Kaskaskia Bend.

The act of June 18, 1878, set apart $10,000 for the improvement of this bend, but the condition is such that, in the light of last year's experience, it has been deemed advisable to allot $10,000 additional from the part of the general appropriation not allotted by Congress.

The expenditures during the year were—

28 piles	$56 00
189.53 cords brush	391 12
2,267.39 cubic yards riprap	3,174 35
Grading	66 40
Engineering and contingencies	826 44
	4,514 31

LIBERTY ISLAND.

No work was done in this vicinity last year owing to lack of means. The incomplete revetments have, in consequence, suffered material injury. The bank for nearly a mile above the revetment is now caving, and at the upper end of the revetment the bank has retreated from 20 to 50 feet from the position it had a year ago. So far as can be determined at the present stage, it is probable that a flat bench extends from the top of the revetment in to the foot of the new bank. If neglected, this bench will be washed out and a destructive current run inside of the revetment. It is therefore designed to apply $20,000 of the recent appropriation to the strengthening and extending of the revetment.

Interruptions of work for want of funds are costly. A year ago the bank was in excellent shape for raising the revetment; now, some 2,000 feet of the upper end will require much additional work to restore it to the condition attained a year ago.

To illustrate the value of the protection of caving bends as an improvement of the navigation, I insert from the files of my office copies of letters received from J. P. Keiser, superintendent of Memphis and Saint Louis Packet Company, premising that at the time these letters were written it was considered a hopeless task to clear the Missouri Chute of snags. Since the revetment of the bank no very great amount of work has been done by snag-boats, and no boat has received injury at the locality. What the condition was may be learned from the following:

LETTER FROM CAPT. JOHN P. KEISER, SUPERINTENDENT OF MEMPHIS AND SAINT LOUIS PACKET COMPANY.

OFFICE OF MEMPHIS AND SAINT LOUIS PACKET COMPANY,
Saint Louis, December 30, 1874.

DEAR SIR: The inclosed letter shows the condition of the river at Liberty Island. You will excuse the liberty I take in sending it to you, when you know the importance it is to us as a packet company, and knowing also that you would, in your official capacity, like to know of the important places to operate when the season comes to operate your work. I have telegraphed to the captain of the *De Russy* of the importance of her coming there, and this morning received a telegram that he would start up to-day, but am afraid the cold weather will prevent her doing any good.

We have ordered our boats to double-trip their freight over the bar on the Illinois side in preference to going down the Missouri side. Five years ago the channel was down the Missouri side, and it cost this company between $60,000 and $70,000 repairs to *Marble City*, *Belle Saint Louis*, and *Adam Jacobs*, and the *Olive Branch* and *W. J. Lewis* both sunk on that side; the last two did not belong to us. Our pilots report that it is impossible for a boat to go through that side without striking.

When the water gets very low the channel goes down on that side in consequence of the gravel on head of Liberty Island. I believe that the boatmen all, without an

exception, agree with me that it is more important *now* to close up the Missouri side of Liberty Island with a dike than any other point on the river.

Hoping you will give the matter due consideration,

I am, yours respectfully,

JNO. P. KEISER,
Superintendent.

J. H. SIMPSON,
Colonel of Engineers, U. S. A.

LETTER OF A. S. LIGHTNER, STEAMER E. C. ELLIOTT, TO SUPERINTENDENT OF MEMPHIS AND SAINT LOUIS PACKET COMPANY.

GRAND TOWER, ILL.,
December 27, 1874.

DEAR SIR: On our down trip I only find 4 feet of water at Sheep Island, on Illinois side of Liberty Island, the way we have been running. The iron steamer tow-boat, Alex. Swift, has just sounded the Missouri side of Liberty Island and reports 6 feet of water, but impossible for any boat to run on account of the logs, as it is a perfect mass of logs from the head to the foot of the island. The water is drawing off very fast down the Missouri side of the island, and I do not think there will be over 3 feet water down the Illinois side of Liberty Island in three days from this time if there is not something done with the Missouri side. Either the logs removed or a dike built across the Missouri side to throw the water back to the Illinois side would be the most advisable plan if it could be done at once. There is one thing certain, if there is not something done you can consider Liberty Island about the foot of navigation for the present.

Yours, respectfully,

A. S. LIGHTNER,
Steamer E. C. Elliott.

Capt. J. P. KEISER,
Superintendent Memphis Packet Company.

LETTER FROM CAPT. JOHN P. KEISER, SUPERINTENDENT OF MEMPHIS AND SAINT LOUIS PACKET COMPANY.

OFFICE OF MEMPHIS AND SAINT LOUIS PACKET COMPANY,
Saint Louis, June 17, 1875.

DEAR SIR: My attention has been called to the fact that the channel at the head of Liberty Island is now very close on to the head of the island, and the probability is that the channel will go down the Missouri side if the water should fall much more. This is the bad place I wrote you about last fall, when we had concluded to lay our boats up rather than run down that side until something was done with it. I got Major Suter to send a snag-boat up to try to take the logs out, but the weather turned so cold that the snag-boat had to turn back on account of the ice, and the river closed, so we have not had to run it yet. The only boat that tried to run it last fall was lost, the tow-boat Babbage; the *Lewis* sunk there the fall before. We have never had one of our own boats to go through there in low-water without striking a break.

* * * * * * * *

We consider the closing of this channel more important than others between this and Cairo.

Very respectfully, your obedient servant,

JOHN P. KEISER,
Superintendent.

General SIMPSON,
Colonel Engineer Corps, U. S. A.

A revetment of the Missouri shore was substituted for the proposed closing of the Missouri chute, and no complaint of difficulty or loss has been made for two seasons.

DEVIL'S ISLAND.

At the date of the last annual report work was in progress on dams Nos. 1 and 2. The gap then mentioned as existing near the east end of dam No. 1 was filled and dam No. 2 raised to a height of 14 feet above

low-water. Both dams are completed except a gap near the west end of No. 1, which has been buried in sand for the past two years, and is liable to be washed away at any time.

Dike No. 1 in the main or Missouri Channel was repaired, and the revetments strengthened.

The expenditures were—

Dam No. 1:	
2,026.68 cubic yards riprap	$3,040 02
Engineering and contingencies	539 60
	3,579 62
Dam No. 2:	
817.36 cubic yards riprap	$1,226 04
Engineering and contingencies	206 24
	1,432 28
Dike No. 1:	
4,153.98 cubic yards riprap	$6,230 97
Grading	63 91
Engineering and contingencies	1,107 91
	7,402 79

As the works are apparently in good condition, it is not intended to expend any part of the appropriation recently made, at this locality.

DICKEY ISLAND TO MOUTH OF THE OHIO.

The work done in the fall season of 1876 not only passed through the winter and spring without injury, but also proved effectual to stop the cutting away of the bank. The upper 500 feet which was above the old spur-dikes assumed a moderate slope as had been anticipated, which slope was revetted during the fall of 1877 to a height of 25 and 30 feet above low-water. The footing was also extended 1,000 feet upstream, and the bank revetted to the top of the defined slope, or about 13 feet above low-water.

A recent inspection showed that no caving had occurred along the protected front, and that the bank whose foot was revetted last fall had assumed a slope ready to receive revetment to a height of 25 feet or thereabouts.

It is proposed to apply the $40,000 recently provided in perfecting the protection between the old spur-dikes, and in extending the regular revetment as far as the means will allow. It will be possible to prepare a considerable extent of foundation, and it is hoped that the means will be provided to complete the revetment to the full extent of the foundation next season.

The expenditures during the year were—

21 piles	$106 96
Grading	255 07
421.63 cords brush	819 08
4,973.49 cubic yards riprap	8,703 61
Engineering and contingencies	1,528 75
	11,413 57

Recurring to the suggestions made last year that no new works be undertaken upon this section of river until those now in hand are completed, according to the estimate then submitted of the cost of completing works then commenced, there remains $315,425.49 to be appropriated

before it would be wise to commence works at any new localities. As said last year, it is not to be disputed that there are many points where works are as urgently needed as at those where they have been commenced; but it is not good policy to attempt more than there is reasonable prospect of being able to complete. To carry on the work on a scale commensurate with its importance, and in the interests of a wise economy would require an annual appropriation of not less than $500,000. With this amount the coming year it would be possible to complete the list of unfinished work given above, and to commence new work at some one or two new points.

SURVEYS.

The only survey was that made to ascertain the damage, if any, done or to be done to riparian owners, at and near Venice, Ill., by reason of works done or to be done by the United States for the improvement of the Mississippi River, the map and report of which were transmitted to the Chief of Engineers under date of April 10, 1878.

EQUIPMENT.

No additions were made during the year. One hull of quarter-boat, being too rotten for further use, was sunk in the foundation of the training-wall at Horsetail Bar, and the quarters were transferred to another barge which had become too weak to carry stone. One good barge was totally wrecked in a storm last fall, being carried by the wind and waves upon the dike at which it was about to be unloaded. This loss and the natural deterioration of the earlier purchases rendered it necessary to make provision for building four new barges, as recommended in the report of last year. Proposals have been advertised for, and will be opened July 20.

All work during the year has been done by hired labor and the purchase of material in open market with highly satisfactory results. Material has been procured in quantities needed at very moderate rates. One chief article of use being riprap stone, the system of purchase in open market enables all quarries located along the river to compete, and affords opportunity for most of them to dispose of rough stone, which, except for riprap, would be of little value. It is intended to continue the system the present year.

The work is located in the collection-district of New Orleans.

Amount of revenue collected at the port of Saint Louis for the fiscal year ending June 30, 1878, was $1,552,723.93.

Construction account.

Name of work.	Amount expended previous to July 1, 1877.	Amount expended during year ending June 30, 1878.	Total cost to June 30, 1878.	Amount required to complete.	Total estimated.
Piasa Island Dam	$23,736 37	$8,596 93	$32,333 30	$8,877 43	$41,210 73
Alton Dam	32,064 85	1,559 07	33,623 92	6,376 08	40,000 00
Sawyer Bend protection	91,940 67	1,874 90	93,815 57	48,396 05	142,211 62
Venice Dikes	36,341 85	.....	36,341 85	3,658 15	40,000 00
Closing Cahokia Chute	20,958 61	5,444 65	26,403 26	78,196 74	104,600 00
Horsetail Bar, dike 1	40,549 53	.....	40,549 53	3,305 37	221,502 86
Horsetail Bar, dike 2	21,911 58	.....	21,911 58		
Horsetail Bar, dike 3	71,065 62	11,626 92	82,692 54		
Horsetail Bar, dike 4	41,290 11	.....	41,290 11		
Horsetail Bar, dike 5	27,079 61	4,674 12	31,753 73		
Horsetail Bar, training-wall	.....	20,398 16	20,398 16	105,601 84	126,000 00
Fort Chartres Dam	36,812 86	.....	36,812 86	9,750 00	46,562 86
Turkey Island	24,463 85	.....	24,463 85	8,101 61	32,565 46
Kaskaskia protection	.....	4,514 31	4,514 31	37,485 69	42,000 00
Liberty Island Dam	5,053 91	.....	5,053 91	.....	5,053 91
Liberty Island protection	35,116 97	.....	35,116 97	8,140 71	43,257 68
Devil's Island, dike 1	58,468 38	7,402 79	65,871 17	17,601 95	150,000 00
Devil's Island, dam 1	46,268 96	3,579 62	49,848 58		
Devil's Island, dam 2	15,246 02	1,432 28	16,678 30		
Cairo protection	18,679 38	11,413 57	30,092 95	142,407 05	172,500 00
Totals	647,049 13	82,517 32	729,566 45	477,898 67	1,207,465 12

Property and material account.

Class of property.	Balance July 1, 1877.	Dr.	Cr.	Balance July 1, 1878.
Office furniture	$380 55	$3 50	$120 00	$264 05
Instruments and survey material	850 00	.....	.....	850 00
Five pile-drivers	10,210 51	132 46	428 00	9,914 97
Barges and quarter-boat	29,969 60	2,103 14	7,714 14	24,358 60
Two tow-boats, one small tug, and expenses	47,262 37	18,761 66	24,254 87	41,769 16
Small-boats	95 99	87 20	125 00	58 19
General expenses of property	18,051 08	1,609 86	.....	19,660 94
Material and quarry privileges	2,807 98	58,660 88	59,389 53	2,079 33
Tools	993 82	463 90	1,199 11	258 61
Quarters for workmen, shops, &c	3,580 70	1,229 97	675 00	4,135 67
Totals	114,202 60	83,052 57	93,905 65	103,349 52

Engineer Office, United States Army, in account with United States.

Dr.		Cr.	
To allotments for surveys and examinations at various dates prior to July 1, 1877	$48,008 77	By expenses of office	$47,273 24
To appropriations for improvement of Mississippi River, between the Illinois and Ohio rivers, prior to July 1, 1877	954,600 00	By general engineering	30,316 62
To appropriation for improvement of Mississippi River, between the Illinois and Ohio rivers, approved June 18, 1878	240,000 00	By surveys	77,069 80
To unpaid percentage on annulled contracts	900 17	By constructions	729,566 45
To liability for labor, &c	374 31	By balance on account of property	103,349 52
		By cash on hand and in Treasury	256,307 62
	1,243,883 25		1,243,883 25

Money statement.

July 1, 1877, amount available	$106,404 14	
Amount appropriated by act approved June 18, 1878	240,000 00	
		$346,404 14
July 1, 1878, amount expended during fiscal year	90,096 52	
July 1, 1878, outstanding liabilities	1,274 48	
		91,371 00
July 1, 1878, amount available		255,033 14
Amount (estimated) required for completion of existing project		6,489,600 00
Amount that can be profitably expended in fiscal year ending June 30, 1880		500,000 00

N 2.

IMPROVEMENT OF OSAGE RIVER.

Work upon this river has been suspended during three years just past, but the act of Congress approved June 18, 1878, having provided the sum of $20,000 for its further improvement, work will be resumed during the coming season.

There being no definite project in progress, no statement of estimated amount to complete existing project can be given and no sum recommended for the fiscal year ending June 30, 1880.

Money statement.

Amount appropriated by act approved June 18, 1878	$20,000 00
July 1, 1878, amount available	20,000 00

APPENDIX O.

ANNUAL REPORT OF LIEUTENANT EDWARD MAGUIRE, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1878.

UNITED STATES ENGINEER OFFICE,
Saint Paul, Minn., July 8, 1878.

GENERAL: I have the honor to forward herewith my annual report for the fiscal year ending June 30, 1878, upon the work of improving Missouri River above the mouth of the Yellowstone.

Very respectfully, your obedient servant,

EDWD. MAGUIRE,
First Lieutenant, Corps of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers U. S. A.

IMPROVEMENT OF MISSOURI RIVER ABOVE THE MOUTH OF THE YELLOWSTONE.

On January 3, 1878, there was mailed from this office to the Chief of Engineers a full report upon "The improvement of the Missouri River above the mouth of the Yellowstone." There is still more to report. The office-work for the year has consisted in the reduction and plotting of the notes and in making estimates for the next season's work.

On the 5th day of April I ordered the assistant engineer to proceed to Benton, Mont., to inspect the river and report upon the result of last season's work. The result is most gratifying. The report is that steamboats can now easily pass Cow Island at low water without (as formerly) "laying a line," and that at Dauphin's Rapids the "improved" portion of the channel is readily recognized.

At the latter point the width of the channel should be increased to 200 feet in order to render it practicable for all classes of steamboats which may ascend the river. The width of 100 feet was ordered last season with the idea of obtaining as great a *length* of channel as possible in one season. The work will be continued during the coming summer upon the basis of last season's work. But two parties should be assigned to the work at this point next year.

The work at Cow Island will be finished this year, and it is expected also that the difficulties to navigation at Grand Island and Two Calf Island will be removed, thus confining the work of next year to Dauphin's Rapids and the reach above.

I would respectfully recommend that an appropriation of $50,000 be requested for the work. I would also renew the recommendation for an appropriation of $5,000 for a survey of the river from Benton to Carroll.

Money statement.

July 1, 1877, amount available	$14,459 63	
Amount appropriated by act approved June 18, 1878	30,000 00	
		$44,459 63
July 1, 1878, amount expended during fiscal year	10,838 50	
July 1, 1878, outstanding liabilities	23 50	
		10,862 00
July 1, 1878, amount available		33,597 63
Amount that can be profitably expended in fiscal year ending June 30, 1880		55,000 00

SPECIAL REPORT ON IMPROVEMENT OF THE MISSOURI RIVER ABOVE THE MOUTH OF THE YELLOWSTONE.

UNITED STATES ENGINEER OFFICE,
HEADQUARTERS DEPARTMENT OF DAKOTA.
Saint Paul, Minn., January 3, 1878.

GENERAL: I have the honor to submit herewith a report upon "The improvement of the Missouri River above the mouth of the Yellowstone."

* * * * * * *

THE SECTION OF COUNTRY TO BE SPECIALLY BENEFITED.

The section of country to be specially benefited by the improvement of the Upper Missouri River is the Territory of Montana, which lies about midway between the great lakes and the Pacific Ocean. Embraced between the forty-fifth and forty-ninth parallels and 104° and 115° west longitude, it is 276 miles wide from north to south and a little over 520 miles wide from east to west. It contains 143,776 square miles, about one-tenth of which (or 9,000,000 of acres) are farming-lands. About one-fourth of the inhabitants are miners, one-eighth stockmen, and the remainder tradesmen and professional men.

All crops are planted in May with the exception of winter wheat, which is sown in October.

Hay is cut and stacked in July, and retains its natural green color until used. This peculiar characteristic is remarkable, and it is said that a load passing along the street at Christmas has the color and perfume of the new-mown hay.

The greatest yield in the line of vegetables is in potatoes, turnips, and onions.

Strawberries of the finest varieties ripen in July, thus furnishing a luscious berry in the warmest month of the year at the rate of 40 to 50 cents a quart.

Tomatoes do not ripen until September.

Some apples are grown in the Territory, but not to any great extent.

The experiments of the Sisters at Saint Ignatius Mission have shown that the country is adapted to the growth of apples, plums, and all varieties of berries.

The spring-wheat flour of Montana is white, of fine quality, and makes most excellent bread, while its buckwheat and corn-meal are said to be equal to the best varieties of those articles in the States.

The chief exports of Montana at present are ores, furs, hides, wool, and cattle.

The imports are machinery, manufactured articles, merchandise, and supplies, such as sugar, coffee, tea, &c.

Mr. George Clendennin, jr., informs me that the greater portion of the furs and robes are collected from the Blackfoot agency, the Marias, and Milk River trading-posts, and from the British possessions, and that Benton is the point from which they are shipped to the East. Benton receives annually about 100,000 robes and furs, and the Crow agency, south of the Yellowstone, about 5,000. About 20,000 pounds of skins are received annually at the Crow agency, and at Benton 150,000 pounds. Over 200,000 pounds of wool are annually shipped to the East. This quantity will gradually increase, and wool of a fine quality will become the great export of Montana.

The beef of Montana is the best in the world, and its mutton rivals the celebrated Southdown. The ease with which large herds are raised and the comparatively slight cost of maintaining them will undoubtedly cause Montana in the future to furnish the Eastern markets with an article of food which will be not only of a finer quality, but cheaper than that with which they are now supplied. The valley of the Musselshell and the beautiful Judith Basin must be developed into magnificent grazing-farms. The herds in Montana are not housed and fed during the winter, but roam at will, and subsist on the plentiful, luscious, and nutritious grasses all the year round.

Of the shipments to the Territory about one-fourth are to Benton and the remainder to Helena via Benton. Helena, the principal distributive depot, is about 140 miles from Benton, the transportation between the two places being by means of wagon-trains.

The establishment of three new posts, and the increase of the number of troops stationed in the Territory, will give an impulse to the settlement of the country by at least a partial removal of the two barriers to such settlement—insecurity of life and property.

In regard to the mineral wealth of the Territory, it has been said that—

> As a gold-bearing country Montana stands next to California, and in silver she ranks first in quality possessed, and second to Nevada in the amount produced.

To enter fully into a discussion of the mining interests is unnecessary for the purposes of this report, the comprehensive and interesting reports of the Commissioner of Mining Statistics being accessible. A few leading facts are, however, here set down.

In his report for 1874, the commissioner gives the following exhibit of the productions for the different years:

1869	$9,000,000
1870	9,100,000
1871	8,050,000
1872	6,068,339
1873	5,178,047
1874	3,844,722

He says that the decrease of the gold-yield is entirely due to placer-mining. Those narrow and rich gulches and bars, to which short ditches could be built by two or three men, have been exhausted. To work the gold-bars, which abound in the numerous valleys, it is necessary to construct long and large ditches, and this can be done only by companies having abundant capital at their command. It is expected, therefore, that there will result a consolidation of the mining-ground heretofore owned in small parcels, and that the yield will be increased provided labor does not remain too high.

The shipments of silver-ore are gradually increasing, and with the introduction of quartz-mills the gold-yield will undoubtedly become

greater. Millions of tons of ore now lie worthless at the mines on account of high rates of transportation.

Montana coal, which is abundant in all parts of the Territory, can be used, as it now is, for blacksmithing, for making steam for locomotive and steamboat purposes, as well as for making gas and smelting iron, galena, and, in short, for every purpose for which soft Pennsylvania coal can be used. According to the reports of the Secretary of the Interior, about 70,000 square miles, or half of Montana, is underlaid with coal-beds; but this I regard as an overestimate.

Iron-ore is equally abundant, and in time Montana can alone supply the needs of the western half of the continent with iron.

In regard to the use of the coal for steamboats, I would add that the varieties of Montana coal (lignite) which I have seen are unfit for such purposes, if used alone, on any boat which is not furnished with locomotive-boilers. It is difficult of ignition and the flame is short. But if used with wood it causes a saving in that article by keeping up a hot body to the fire, while the wood supplies the long, lapping flame.

THE VALUE OF THE MISSOURI RIVER AS A LINE OF COMMUNICATION AND TRANSPORTATION.

The Missouri River and the common roads connecting the Territory with the Union Pacific, Central Pacific, and Utah Northern Railroads, are at present the only regular lines of communication with Montana. Of these, the river is by far the most important; it is *the* great route. The completion of the Union Pacific and the low water of 1869 induced the merchants and shippers of Montana to contract for the transportation of their freight by the railroad, it having lowered its rates during the season of high water in order to compete with the boats. Time, however, proved the superiority of the water-route in spite of the obstacles to navigation, and the bulk of imports returned to the river.

The Helena Independent, in one of its editorials, says of the river:

Freights can be laid down at Benton at such a low rate that successful competition from any other source is next to impossible. At any rate it is the route that Montana must look to for cheap freights until she gets a railroad, and, therefore, it is the duty of her people to put forward their best efforts to secure measures that will aid in making this great natural highway available for the immense commerce that will pass over it for the next ten years. It is desirable that the river navigation should be kept up from the time ice breaks up in the spring until it is closed in the fall by ice.

The above-quoted statements are true, but should be stronger in this, that the Missouri River will always be an important line no matter how many railroads may be built in Montana.

It is the intention to carry the Northern Pacific Railroad along the south bank of the Yellowstone. This road will, of course, receive part of the freight to and from Montana, as does the Union Pacific at present, but there is a large extent of the Territory which from its greater convenience to the river and from the very nature of its productions must find an outlet for those productions in the Missouri.

It is impossible to say when the Northern Pacific will be finished or in operation, and it is also impossible to state what the freight-rates on that road will be. But whatsoever they may be, the Missouri River will always receive the bulky matter as better adapted to its carriage at rates to which the railroad cannot safely descend; and it will also by its competition keep at a reasonable figure the rates on those articles which will naturally seek the railroad for rapid transit. The river, then, will be indispensable not only as a line of transportation, but as serving by its competition to keep down the freight-rates on the railroads.

* * * * * * *

It is proposed now simply to submit such an exhibit of the commerce

of the river last season as the information which could be obtained will permit.

Messrs. J. G. Baker & Co. of Benton, who ship over one-fourth of the freight which goes up the river, have in compliance with my request kindly furnished me with the following information:

During the last season 25 steamers arrived at Benton, landing 5,283 tons of freight and about 1,500 passengers. These boats carried down the river 3,200 tons of freight and about 500 passengers.

The imports consisted of merchandise for the merchants of Montana, supplies for the Army and Indians and the Northwest Mounted Police of Canada.

The exports consisted of ore, wool, hides, and furs; principally of ore.

Owing to the Indian troubles only six steamers landed at Cow Island, parties fearing to ship freight by that route as it would have to be carried overland in wagons to Benton.

The additional cost of transportation via Cow Island has been 2½ cents per pound, or about three times as much as it would have been if boats could have carried the freight to Benton.

The average amount of freight landed at Cow Island annually is 500 tons, causing an extra annual expense to the government and citizens of $25,000. In addition to this both the government and citizens ship by the Union Pacific Railroad (a circuitous route requiring 450 miles of wagon transportation) at a heavy expense. This causes a difference in freights of at least $75,000. This would not occur were the river navigable during the whole season. Since 1870 the commerce of the river has increased 50 per cent.

During the month of September about 60 tons of government freight were burned at Cow Island by the Nez Percés. This freight was lying at the landing awaiting transportation to Benton, and the loss could not have occurred if the boats had been able to reach the latter place.

The number of troops stationed in Montana has been increased, and it naturally follows that a greater amount of supplies will be sent to the Territory hereafter. It would be a great saving to the government to be able to ship these supplies direct to Benton by boat, and thence haul them by wagons to the different posts, at the rate of 1¼ cent per 100 miles.

The following is a classified schedule of exports and imports, *via* the river, for 1877:

EXPORTS.

Ore and bullion, 1,225 tons; average value per ton, $750; total value	$918,750 00
Wool, 208,459 pounds; value	72,960 75
Buffalo-robes, 50,512 robes; value	202,048 00
Antelope, elk, and deer skins, pounds, 68,530; value	12,335 40
Bear-skins, 61 skins; value	305 00
Wolf-skins, 2,034 skins; value	7,051 45
Beaver-skins, 6,703 pounds; value	6,703 00
Hides, 15,267 hides; value	45,801 00
Mixed furs, value	2,150 00
Sheep-skins, 1,482 skins; value	592 80
Cattle, 112 head; value	2,240 00
Fort Macleod shipments.	
595 tons, value	303,600 00
Cypress shipments.	
350 tons, value	180,000 00

IMPORTS.

Montana freight, 4,648 tons; average value per ton, $300; total value	$1,394,000 00
Canadian freight, 1,025 tons; value	310,000 00

Of these imports, 390 tons were landed at Cow Island.

The total value of the commerce of the river was $3,458,536.60.

It is perhaps well to state here that the river is navigable to Benton from about May to the middle of August, and that from the latter date to about the middle of October boats land their freight and passengers at Cow Island.

The fact that freight must be rehandled at Cow Island (rehandling being always a source of increased expense) and that transportation by wagons is more costly than that by boats has led the people of Montana to ask that the river should be improved in order that the annual period of navigation to Benton may be extended.

HISTORY OF THE WORK.

As early as the year 1867 Capt. C. W. Howell, Corps of Engineers, U. S. A., submitted a report upon the Missouri River, which was published in the Report of the Chief of Engineers for 1868.

In 1872 a similar report by Mr. Thos. P. Roberts, Asssistant Engineer of the Northern Pacific Railroad, was, upon the recommendation of the Chief of Engineers, United States Army, printed by the War Department.

Again, in 1875, Maj. Charles R. Suter, Corps of Engineers, U. S. A., reported upon the improvement of the Missouri River above the mouth of the Yellowstone.

The act of Congress approved August 14, 1876, appropriated the sum of $20,000 for the "improvement of the Missouri River above the mouth of the Yellowstone," and a letter from the Chief of Engineers, dated March 21, 1877, informed me that, with the sanction of the Secretary of War, I was assigned, in addition to my other duties, to the charge of the work, under the direction of the Chief of Engineers.

The three reports referred to above furnished the only data upon which to base a project, but inquiries in reference to the proposed work were at once submitted to the different companies whose boats navigate the Missouri, and the replies thereto agreed with the reports in this, that Dauphin's Rapids were the greatest obstructions in the river, and should receive the first attention.

Consequently the project submitted having been approved, a party, consisting of one assistant engineer, one recorder, one overseer, and twenty-three laborers, were organized and sent to Dauphin's Rapids, leaving this city June 11, and arriving at the Rapids June 25, 1877.

The scene of operations being so remote from any depot of supplies, all the men and all of the material, with the exception of the few additional articles which the development of the work called forth, were sent from this city.

Authority was obtained for the purchase of rations from the Subsistence Department, and the great bulk of such supplies was purchased at Fort Buford.

A company of the Seventh Infantry, commanded by Capt. T. S. Kirtland, was detailed as escort. I am very much indebted to Captain Kirtland for his uniform great courtesy and the interest in the work which he displayed during the whole season.

My annual report for the last fiscal year stated that it was the intention to procure a channel 300 feet wide, with a depth of 4 feet at low-water stage; but upon visiting Dauphin's Rapids I found that this project would have to be changed. Instead of finding simply a few rocks distributed here and there through the channel, the bed of the river proved

to be literally paved with rocks, varying in size from 6 cubic inches to 3 cubic yards. It would have been impossible in one season to have obtained a channel 300 feet in width. It would have been equally impossible to have obtained one 4 feet in depth. Consequently I directed that a channel only 100 feet in width should be cleared to the level of the gravel-bed, and that wing-dams should be constructed, as shown on the map* of Dauphin's Rapids appended. All of the soundings taken are not plotted on this map. By means of these dams the whole volume of water would be thrown into the channel, and secure a depth of more than 30 inches free of rocks. Such a channel is considered to be sufficient, as the boats which navigate the Upper Missouri are of about 30 feet beam, and have a draught of about 30 inches for a full load.

It was not until the 13th of August that the stage of the river was such as to allow of any work in the way of removal of rocks. The work once commenced, however, good progress was made until September 26, when the work at that point was abandoned, for the reason that Major Ilgis, Seventh Infantry, ordered the escort to Cow Island, and the working-boats were needed for transportation. The report of my assistant, which will be found appended, is full as to this matter. While regretting that the work at the Rapids could not be finished, thus making a "clean job" of it, still it is to be considered that work was done at Cow Island which is of incalculable benefit, and which could not have been done had the work at Dauphin's been continued.

The season's operations may be summarized as follows:

At Dauphin's Rapids a channel 100 feet wide and 1,800 feet long was cleared of rocks. Several bunches of rocks were also taken out below the foot of this channel. The number of rocks removed was 2,400, measuring 286.5 cubic yards, and requiring for their removal 128 dynamite blasts, in addition to the ordinary grappling. A dam to close the right chute was carried out to a distance of 130 feet. The work on this dam was discontinued because it was found to be throwing water into the channel and interfering with the removal of the rocks. It has a crest of 6 feet, an upstream slope of $\frac{1}{2}$, and a downstream slope of $\frac{1}{1}$. It contains 200 cubic yards of stone. The upstream slope is covered with a layer of gravel, 50 cubic yards having been used for this purpose. In addition, about 1,000 cubic yards of stone were collected on the banks. This amount will suffice for the completion of the above-mentioned dam and for the construction of the proposed one above it. Three other short dams (containing about 60 cubic yards of stone) were constructed near the left bank.

At Cow Island all of the rocks were removed from the channel, and the right chute closed by a dam, thus securing at the time work ceased a clear channel varying in depth from over 30 inches to 5 feet. As the dam becomes tighter from the deposition of sediment, more water will be thrown into the channel. This dam is 419 feet long, has a crest of 8 feet, an upstream slope of $\frac{1}{3}$, a downstream slope of $\frac{1}{1}$, and contains 710 cubic yards of stone.

The escort left Cow Island October 14, and the party started down the river October 21, arriving in Saint Paul November 13.

Water-gauge readings were made at Cow Island during the season, but the record was burned by the Nez Percés when they crossed the river at that point, September 23. Similar observations were made at Carroll.

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* The maps and sketches referred to herein are on file in the office of the Chief of Engineers.

IMPROVEMENT OF THE RIVER.

A very full and complete description of the Missouri River is given in Howell's report, and it is therefore unnecessary to enter into any minute details. I will simply state that the river between Benton and Carroll may be considered as having a fixed regimen, and the work necessary for its improvement is simple in its character and will be permanent in its effects. There is plenty of water, the low-water discharge at Dauphin's Rapids, computed from current observations made last summer, being 11,062 cubic feet per second. The surface rate of current for low-water is 3.2 miles per hour, and for a medium high stage it is 4.3 miles per hour. The average fall for a distance of 3,200 feet is at the rate of 8.9 feet, and for 1,000 feet of that distance the fall is at the rate of 11.42 feet per mile.

Before making any suggestion as to the work which should be done in this portion of the river, I shall refer to the lower reach of the stream or that between Carroll and the mouth of the Yellowstone.

The obstructions to the navigation of this latter portion consist of snags and shifting sand bars. The snags, however, are not of frequent occurrence, and as the boats never run at night save when there is a bright moon, and as they run entirely by the appearance of the water, I do not consider the snags of sufficient importance to call for an expenditure of time and money for their removal. I understand, too, that the ice each year removes a great portion of them and that their places are supplied by new ones during each flood. I have learned of no boat which has ever been injured by snags in the Missouri above the mouth of the Yellowstone.

Sketches 9 and 10, the former of Bird's Island, about 15 miles below Carroll, and the latter of Spread Eagle Bar, will convey a slight idea of the nature of the obstructions due to shifting sand bars. While these bars cause delays still they are not impassable and boats can "get over" by "sparring" or "laying lines." The works which would be required for a successful removal of this class of obstructions would be so extensive and so costly that they would be entirely disproportionate to the interests to be considered, besides possessing always the element of uncertainty of permanency. While it is to be desired that boats should be able to go to Benton during the whole season, still the delays experienced at these lower points are not of an importance sufficient to warrant the outlay necessary for the removal of the causes of such delays. There are it is true occasional places where rocks are to be found in the river, but until their number be increased or their positions be so changed as to present greater obstacles than they now do I do not consider them deserving of attention.

But between Carroll and Benton the obstructions are serious, consisting of rocks and gravel bars which do not shift. The work of improvement should at present be confined to this reach.

Then follows a brief description of the obstructions encountered, starting from Benton. The sketches referred to are drawn to no scale, as no surveys have been made of the localities, and they are submitted simply to convey an idea of the nature of the work to be done.

1. *Shonkin Bar* (sketch No. 1).—Two bars are found at this place, the upper one dry and the lower one submerged at all times. From the upper bar a gravel reef makes out obliquely across the stream to the point. At low water stage there are only 20 inches of depth on the reef. In the sketch the full line indicates the high-water channel, and the broken one the low-water channel. To improve this place it is proposed

to build out from the upper bar on the reef a wing-dam so as to confine the water to a narrower channel and thus obtain an increased depth on the reef. The term reef is here used arbitrarily (and will be so used throughout) to indicate a submerged gravel-bar as distinguished from the larger and more sandy bars which during low water assume almost the proportion of islands.

2. *Acker's Island* (sketch No. 2).—A gravel reef makes from the head of the island toward the right bank, leaving a very narrow and crooked channel. The two heavy dots indicate a snag and rocks which should be removed. The left chute should be closed.

3. *Ackley Bars.*—The river is here divided into two chutes by bars, and there are rocks in the channel near the foot of the bars. The left chute should be closed by a dam and the rocks removed.

4. *Bluff Rapids* (sketch No. 3).—The river is here divided into two chutes by Gould Island, and there are a few rocks near the head of the channel or right chute. The left chute should be closed and the rocks removed.

5. *Kipp's Rapids.*—Broad, shallow, and full of rocks. Water very swift. A good channel should be made by the removal of some of the rocks.

6. *Eagle Reef* (sketch No. 4).—The channel here is very narrow and crosses the rocks as shown in the sketch. The chute A closes of itself during low water. Some of the rocks should be removed.

7. *Hole in the Wall.*—At Hole in the Wall the river is divided into different chutes by three bars. The water is shallow, and an increase of depth should be obtained by closing some of the chutes.

8. *McKnight's Bars.*—Here the channel is to the left of the bars; is very narrow, and contains rocks which should be removed.

9. *Rapids half a mile below McKnight's Bars* (sketch No. 5).—The river at this point is obstructed by two reefs of bowlders, as shown in the sketch. Rocks should be removed from the point of each of these reefs so as to straighten the channel.

10. *Double Islands.*—At the Double Islands, just below the Niches, the river is divided into two chutes, the "suck" being to the right. Bowlders lie across the channel at the head of the islands, running obliquely up stream toward the right bank. These bowlders should be removed.

11. *Pablos Rapids.*—The Pablos Rapids commence at Point of Rocks, and are quite long and broad. There is a sufficient depth of water, but the channel is filled with bowlders. A free channel should be made by the removal of some of the bowlders.

12. *Holmes's Rapids* (sketch No. 6).—These rapids, commencing above Birch Creek, are over a mile in length. The water is very swift, and there are a number of bowlders in the channel. Boats cannot pass these rapids during low water on account of the bowlders. A clear channel should be made by removing some of them.

13. *Lone Rock Rapids.*—Here the river is divided into two chutes by a very long, narrow bar which runs up close to the right bank, leaving a narrow but deep channel, which, however, has situated in it a large rock some 12 feet in diameter, and which cannot be passed in low water. The removal of this rock would make the channel a good and safe one.

14. *Big Bowlder.*—This bowlder projects about 2 feet above low water, and has damaged several boats. It should be removed.

15. *Gallatin Rapids.*—The obstruction at this point consists of a broad diagonal reef of bowlders. It is difficult for even a mackinac to pass without hitting. A channel should be made here by removing bowlders.

16. *Bear's Rapids.*—At this point there is a bad reef of bowlders which cannot be passed by steamboats during low water. A channel should be made by removing bowlders.

17. *Dauphin's Rapids.*—At a small island above the rapids there are a few rocks in the channel which should be removed. The work on the Rapids themselves should be continued and finished. For a distance of about 8 miles below the foot of the rapids proper the channel is obstructed at various places by rocks which should be removed.

18. *Magpie Rapids.*—The removal of rocks is all that is required here.

19. *Bird's Rapids.*—These rapids are caused by a rocky reef which extends out from the right bank. There is plenty of water, but the channel is only about 20 feet wide at low water and should be widened by the removal of some of the rocks.

20. *Sturgeon Island.*—There is plenty of water in the channel, but at the head of the island there is a "suck" into the left chute and boats are sometimes drawn over on to the bar. This can be prevented by closing the left chute with a dam.

21. *Snake Point.*—The lateral chute here should be closed by a dam.

22. *Cow Island.*—The dam closing the middle chute and marked on the map "Proposed Dam," should be built and the upper one should be finished. There should also be a short spur at the foot of the islands.

23. *Grand Island* (sketch No. 8).—The difficulties at this point are caused by two gravel reefs, one at the head and the other at the foot of the island. The water on these reefs is very shoal, being only 21 inches in depth at low water stage. All of the lateral chutes should be closed by dams, and it will probably be found necessary to rake the bars and build wing-dams to raise the water on the reefs.

24. *Two Calf Islands* (sketch No. 7).—At this point the lateral chutes should be closed by dams.

In my annual report for the last fiscal year I recommended an appropriation of $30,000, but I discovered upon a personal examination of the river last summer that the obstructions were much more extensive and demanded more labor and time for their removal than I was led to suppose. The above amount was proposed under the supposition that the obstructions to navigation were so slight that *one* party would suffice for the work. The annual period of time during which rocks can be economically removed from the river is very short, being only *two* months. The rapidity of the current and the depth of water are too great before about the middle of August to permit of work under water, and operations should not be continued later than October 20. The only project then is to increase the number of working parties, and distribute them at different points along the river. I would, therefore, respectfully recommend that at least three parties be employed on the work and that an appropriation of $75,000 be asked for, as I consider that amount the least that can be profitably expended in one season and produce *apparent* practical results. I am of the opinion that with that amount the river can be improved to such an extent that boats will be enabled to go to Benton during the whole season.

I would also recommend that application be made for an appropriation of $5,000 for a survey of the river from Benton to Carroll. This survey can be made in one season, and is indispensable for an intelligent consideration of the improvement of the river. As it now is, having no other knowledge than that boats have experienced difficulties at certain points, it is impossible to do more than to estimate for the maintenance of three parties and trust to the developments of the coming season for accurate and detailed information. It may be that in the course of

the work at the points enumerated above, difficulties at other points will be discovered or developed.

To repeat, at least three parties should be organized in this city, and, provided with all the necessary material and appliances, be sent, one to Shonkin Bar, one to Dauphin's Rapids, and the third to Cow Island. The first party should finish all necessary work at Shonkin Bar, and then proceed in succession to Pablos, Holmes's, Lone Rock, Gallatin, and Bear's rapids. These are the most important obstructions, and their removal is absolutely necessary to enable boats to reach Benton. The second party should finish the work at Dauphin's Rapids, and then turn its attention to that portion of the river between Dauphin's Rapids and Cow Island. The third party should complete the work at Cow Island, and then proceed in turn to Grand Island and Two Calf Island.

Great credit is due to Mr. H. E. Stevens, assistant engineer, for the ability and energy which he brought to bear upon the work.

I have the honor to forward herewith tracings of detailed maps of Dauphin's Rapids and Cow Island.

Very respectfully, your obedient servant,

EDWD. MAGUIRE,
First Lieutenant of Engineers.

The CHIEF OF ENGINEERS, *U. S. A.*

REPORT OF MR. H. E. STEVENS, ASSISTANT ENGINEER.

UNITED STATES ENGINEER'S OFFICE,
Saint Paul, Minn., December 20, 1877.

SIR: I have the honor to render the following report upon the improvement of the Missouri River above the mouth of the Yellowstone River:

Orders were received from you to prepare for the work May 10, 1877. An uncertainty as to the exact nature of the work to be done, coupled with the impossibility of obtaining a supplementary outfit, made it necessary to provide liberally for contingencies.

Lumber was purchased and boats framed and packed at Minneapolis. Tools and camp-equipage were bought and men hired here.

Upon the 11th of June I left Saint Paul *via* the Northern Pacific route with a party consisting of a recorder, foreman, blacksmith, carpenter, cook, and 20 men, including boatmen and quarrymen. After a delay of two days at Bismarck, I took the steamer Benton the morning of the 16th for Dauphin's Rapids, this being the place about which steamboatmen made the most complaint and at which the first work was to be done.

Arriving at Dauphin's Rapids upon the 25th of June, I commenced building the boats, and was ready for work upon the 17th of July.

Dauphin's Rapids are caused by an excessive fall and an unusual widening of the river. There is no navigable 3-foot channel clear of rocks for a distance of 3,100 feet. The lower part of the rapids is divided by a gravel bar 2,000 feet long, 300 feet wide, projecting about 2.5 feet above low-water. The main channel assumes nearly the shape of the left bank. The chute to the right of the bar is used by boats during high water. In places the bottom is paved with bowlders varying in size from 6 cubic inches to 3 cubic yards; these are often found in groups, one or more large rocks forming the nucleus about which the others gather and take their places in the most compact form. Again it is of coarse gravel, studded with bowlders buried deep, often reaching through to the subsoil of clay.

The low water discharge of the river at Dauphin's Rapids is 11,062 cubic feet per second; of this, 5,047 cubic feet per second flows to the right of the bar.

The surface-rate of current at low water in the main channel is 3.2 miles per hour; at a medium high stage it is 4.3 miles per hour. Only the better boats upon the river can stem it without the use of a line.

The average fall for 3,200 feet is at the rate of 8.9 feet per mile, and for 1,000 feet of this distance it is 11.42 feet per mile. The slow rate of the current compared with the great fall can be accounted for by the fact of the shoal water and the presence of so many bowlders.

The improvement devised was to remove all bowlders in the upper 700 feet of the shoal to the depth of 3 feet, and for the remainder of the way to remove them to a

depth of 2.5 feet; then to build two wing-dams, the lower one closing the chute to right of the bar, the upper one projecting from the right bank opposite the head of the 2.5-foot channel; the dams to be of bowlders, which could be obtained along the banks within a mile of the proposed sites; the bowlders taken from the channel to be so disposed along the left bank as to contract the width of the river 100 feet.

Upon the 19th of July the derrick-boat was anchored in the channel, and an attempt made to commence clearing it of rocks. The current was found too swift and the depth of water too great to allow of the profitable prosecution of the work, so that it was abandoned, to wait for a lower stage of water. In the mean time work of gathering and transporting rocks for the wing-dams was carried on.

Between the 19th of July and the 13th of August several unprofitable efforts were made to remove rocks. Upon the 13th of August I anchored the boat over one of the bad prominent bunches in the lower part of the rapids (one of the bunches which steamboatmen had represented as a single rock), and was able to do good work in its removal. After taking out several groups near the foot of the rapids, and thus gaining a good idea of the magnitude of the work, I found that it would be impossible to clear a channel of the proposed width (300 feet) during the season with the appliances at hand. I therefore concluded to first secure a channel of 100 feet in width. This being properly buoyed out, work was commenced at the head of the rapids, and all bowlders taken out to a depth of 3 feet. A daily progress of 40 linear feet of channel was made for a distance of 700 feet. Over this portion the water was deep, but the bottom was covered with large rocks projecting above the required depth; many of them required blasting.

At this point, the water becoming shoaler, dependence was placed upon the wing-dams to raise the water surface, and the rocks were taken out to a depth of 2.5 feet. This was the most troublesome portion of the rapids to clear of rocks. As there were many places where the even gravel bottom was covered by slack 2.5 feet water, it was necessary to remove all the small stones. They were deeply bedded in coarse gravel, and required moving from their beds by the use of dynamite before they could be grappled. During the progress of the work on the rapids, the gathering of rocks for the wing-dams was continued and the lower one built for 130 feet, when it commenced to throw water into the main channel, and work upon it was immediately stopped. There are in the dam 200 cubic yards of rock. The upper slope is covered with gravel, 50 cubic yards having been used. The dam is 6 feet wide on top, front slope 2 to 1, back slope 1 to 1. Besides the rock in the dam, there are gathered upon the banks about 1,000 cubic yards, a sufficient amount to construct the remaining portion of the lower dam and all of the upper dam.

The work had progressed satisfactorily until the 26th of September. There had been taken from the channel 2,400 bowlders of over a cubic foot each, in all measuring 286.5 cubic yards. They were placed along the left bank. For the removal of these bowlders, 128 blasts were exploded. At this time the channel had been cleared for a distance of 1,800 feet from the head of the rapids, including the worst of the shoal, and besides several prominent bunches of rocks had been removed below this point when work was first begun in the higher stages of water.

There was still sufficient time to clear the remaining portion of the 100-foot channel and to build the dams, thus completing the work at this point the present season. Upon the above date orders came to Captain Kirtland, in command of the escort, to go at once to Cow Island, the Nez Percés having crossed there a few days before.

Captain Kirtland was depending upon my boats for the transportation of his command, and there was no other means at hand. I hesitated as to whether I would leave or not. He informed me that he would be obliged to seize such of my boats as would be required by his command. This made it necessary for me to go to Cow Island or resist.

I was thus obliged to leave the work at Dauphin's when everything seemed propitious for its completion this season.

The damage thus caused to the river improvement and to the interests of navigation was very great.

Had the work been finished at Dauphin's (this being the worst place on the river), nearly all of next year's freight could have been carried through to Benton by river. As it now is, it will be necessary to wait for low water for the completion of the work, and freight taken up river during the latter part of the season will have to be unloaded below, as formerly, and hauled overland.

I went to Cow Island the 28th of September. The river here is divided by two islands, separated by a narrow chute. About two-thirds of the water passes down the main channel to the left. From the conformation of the river and its banks the main channel should be along the right bank. This channel is very narrow, and in places rocky and swift. The main channel to the left is obstructed by two coarse gravel bars and by a few rocks. The fall for a distance of 6,000 feet is at the rate of 5.16 feet per mile; the rate of the current is 2.7 miles per hour. The improvements proposed were to remove the rocks in the main channel and to close the two island chutes by low water dams. Dams to be of bowlders.

The rocks were removed and the dam at the upper and main chute was completed October 21, when work was suspended for the season.

The cross-section of the dam put in here was 8 feet top, 3 to 1 upper slope, 1 to 1 lower slope. There were 710 cubic yards of rock placed in the dam. The working boat and outfit were taken to Carroll for safe-keeping. The boats were pulled out upon high ground. The afternoon of the 25th October I started for Bismarck in mackinaws. I was able to make from 50 to 75 miles per day, arriving at Fort Buford November 2. Upon the night of the 4th I camped at the mouth of the White Earth River, 205 miles from Bismarck.

For several days the weather had been cold. At 11 p. m. the slush-ice commenced to run, and by daylight the river was filled with cakes of large dimensions.

I started, as usual, the morning of the 5th, and floated along in the ice till noon, when I reached Knife River.

The weather still continued cold. The ice had been forming fast all the morning, and I did not consider it safe to run on. I was fortunate in finding freight-teams, and employed them to take my camp-equipage to Bismarck.

I reached Bismarck the 11th, and took the evening train for Saint Paul.

The Missouri River above the mouth of the Yellowstone for a distance of 215 miles (32 miles above Fort Peck) bears many of the characteristics of the lower river. There are a number of widespread bars, where shifting sands make an uncertain channel. They do not become impassable, nor do they damage boats, but often cause delays. From this point to Carroll, 120 miles, the river, with few exceptions, is good. In character it is between the shifting sand-bar river below and the rocky and rapid river above. There are a few places that will require improvement. These, by the removal of a few rocks and the building of short dams, will be made permanently good. From Carroll to Benton, 167 miles, the river is rapid, channel fixed, banks stable, bottom of gravel, and bowlders of frequent occurrence.

This is the portion of the river that requires immediate attention. The bad places are caused either by gravel bars or by bowlders. They are similar in character to Dauphin's Rapids and to Cow Island, and can be improved in the same way.

A complete survey of the river from Fort Benton to Carroll can be made during the months of August and September, at an expense not to exceed $5,000. This would be of great value in the intelligible improvement of the river, and would cost but little more than the disconnected surveys which must be made at all points improved or examined.

The disconnected surveys have to be made by laborers, unskilled in the work, and must often detain working parties. Were this survey completed and the improvements planned for the different points, working parties could commence (where only wing-dam improvements are needed) a month earlier than they otherwise can. I would respectfully recommend that such a survey should be made.

With this report I submit two maps, showing the river at Dauphin's Rapids and at Cow Island, with the locations of the proposed wing-dam improvements.

I wish to inform you of the courtesy and kindness of Capt. T. S. Kirtland. He did everything in his power to serve the interests of the work.

Very respectfully, your obedient servant,

H. E. STEVENS,
Assistant Engineer.

Lieut. EDWARD MAGUIRE,
Corps of Engineers, U. S. A.

APPENDIX P.

ANNUAL REPORT OF MAJOR F. U. FARQUHAR, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1878.

UNITED STATES ENGINEER OFFICE,
Rock Island, Ill., July 11, 1878.

GENERAL: I have the honor to transmit herewith my annual reports of operations at the several works under my charge during the fiscal year ending June 30, 1878.

I am under great obligations to Mr. M. Meigs, United States civil engineer, and Messrs. E. F. Hoffmann, C. W. Durham, and J. L. Gillespie, assistant engineers, for the cordial, intelligent, and faithful service they have rendered the United States.

Very respectfully, your obedient servant,

F. U. FARQUHAR,
Major of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

P 1.

IMPROVEMENT OF UPPER MISSISSIPPI RIVER.

Col. J. N. Macomb, Corps of Engineers, was in charge of this work until November 15, 1877, when he was relieved by Maj. F. U. Farquhar, Corps of Engineers. The work accomplished by the snag and dredge boat Montana is as follows:

SUMMARY.

Snags extracted	94
Trees pulled back	68
Overhanging trees removed	6,358
Island numbers established	150
Channel-marks established	19
Water-gauges established	2
Bench-marks established	45
Number of scrapes made	240
Boats assisted	18
Miles of survey lines	4½
Number of soundings	9,830
Number of localities examined	15
Miles run	4,482

The boat was under the charge of C. W. Durham, assistant engineer, and he deserves much credit for the amount of work the boat accomplished under his direction.

During the past winter a general map of the Mississippi River, in 26 sheets, from the Falls of Saint Anthony to the mouth of the Illinois, was reduced from all the means of information in the office, for the purpose of having it photo-lithographed and distributed to river men to

induce, if possible, a uniform nomenclature of localities, and on which might be shown changes as determined by future observations. This map is in no sense a hydrographic map, as the principal basis of it is the United States land surveys.

During the latter part of the summer and fall of 1877 occurred the lowest stage of water between Saint Paul and Acton since 1864.

Under instructions from Col. J. N. Macomb the low-water was marked at 61 stations and referred to permanent bench-marks. At the same time soundings were made on the principal bars and crossings.

The low-water stage was about 9 inches higher than that of 1864.

These observations and a careful record of gauge-readings during the present year in connection with surveys proposed to be made will add much to the knowledge necessary for a proper study of the river before a complete plan for its improvement can be made.

The steamer Montana is worn out, and is so water-logged that it draws too much water for its work. It is thought that a new wooden hull can be built and the machinery from the present hull transferred and the *Montana* operated for the present season for the amount of money now available. The new hull should be a little wider, and should not be weighted down with the great and unnecessary amount of upper works now on the *Montana*.

Mr. M. Meigs, United States civil engineer, was, under the direction of Col. J. N. Macomb, Corps of Engineers, in general charge of the improvement of the Upper Mississippi and the special works of improvement on the river, except Rock Island and Des Moines Rapids. A reconnaissance of the Mississippi River between the mouth of the Illinois River and Des Moines Rapids was made and some of the worst bars examined, but more exact surveys must be made before plans and estimates can be made.

In this report the permanent improvement of the river is not considered, as Congress has made separate appropriations for the permanent works, and under that head separate reports will be made. Until the permanent improvements are made the snag-boat is necessary, and $30,000 should be appropriated to operate it for the fiscal year ending June 30, 1880.

ABSTRACT OF APPROPRIATIONS MADE FOR IMPROVEMENT OF UPPER MISSISSIPPI RIVER.

By act approved March 2, 1867	$96,000 00
By allotment from appropriation of July 25, 1868	26,000 00
By act approved July 11, 1870	36,000 00
By act approved March 3, 1871	42,000 00
By act approved June 10, 1872	42,000 00
By act approved March 3, 1873	25,000 00
By act approved June 23, 1874	25,000 00
By act approved March 3, 1875	25,000 00
By act approved August 14, 1876	30,000 00
By act approved June 18, 1878	41,500 00
	388,500 00

Money statement.

July 1, 1877, amount available	$16,752 21	
Amount appropriated by act approved June 18, 1878	41,500 00	
		$58,252 21
July 1, 1878, amount expended during fiscal year	14,663 03	
July 1, 1878, outstanding liabilities	850 21	
		15,513 24
July 1, 1878, amount available		42,738 97
Amount that can be profitably expended (operating snag-boat) in fiscal year ending June 30, 1880		30,000 00

STATISTICS OF COMMERCE AND NAVIGATION.

Lumber.

The most important business interest on the Upper Mississippi and its tributaries is the lumber trade, giving employment to great numbers of men and upward of 100 steamboats which are now used in guiding and propelling rafts. Between the mouth of the Chippewa and Saint Louis there are 73 mills on the main river, with an annual *day* sawing capacity of 600,000,000 feet, employing 12,000 men and representing $12,000,000 of capital. The estimated product of white pine floated into the Mississippi River in 1877 is 750,000,000 feet, including logs, lumber, shingles, &c.; in 1876, 1,350,000,000 feet. The amount of logs run into the Mississippi from the Saint Croix, Chippewa, and Black Rivers, in 1877, was about 305,000,000 feet; in 1876, 515,000,000 feet.

The great falling off in the quantity of logs and lumber received from the tributaries and in the manufactures of the various mills during the season of 1877, as shown in the above statements and the following tables, is due partly to the low water in the Black, Chippewa, and Saint Croix, which caused the drives to come slowly and which left at the close of the season a large percentage of the logs hung up, and partly to the extreme low water in the Mississippi during the rafting season and the consequent difficulties of navigation impeding the transportation of logs to their destinations at the various mills on the main river between the mouth of the Saint Croix and Saint Louis.

The following table shows the amount of lumber manufactured on the Upper Mississippi and tributaries and the amount on hand at close of season in 1877, 1876, and 1875.

I omit the product of the Wisconsin River in this statement, inasmuch as nearly all the lumber made on that river is shipped by rail, and not coming into the Mississippi need not be considered in this connection as not bearing upon the question of improving the navigation of that river.

Most of the figures were obtained from the Northwestern Lumberman, published at Chicago, Ill.

Table showing lumber business of Upper Mississippi and tributaries, for 1877, 1876, *and* 1875.

Names, localities, &c.	Lumber manufactured.			Lumber on hand at close of season.		
	1877.	1876.	1875.	1877.	1876.	1875.
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Farnham & Lovejoy, O. C. Merriman & Co., W. D. Washburn, and 18 other firms at Minneapolis and above	140, 874, 084	203, 750, 000	161, 469, 000	60, 423, 348	98, 860, 000	80, 582, 000
Laird, Norton & Co., W. & J. Fleming, Youmans Brothers, and 14 other firms between Minneapolis and Dubuque	62, 305, 000	72, 600, 000	70, 700, 000	31, 830, 000	47, 515, 000	43, 106, 000
Ingram, Kennedy & Day, Dubuque Lumber Company, and 3 other firms at Dubuque	21, 250, 000	20, 400, 000	14, 000, 000	10, 850, 000	16, 750, 000	6, 500, 000
W. J. Young & Co., C. Lamb & Sons, Lamb Bvng Company, and 9 other firms at Clinton, Lyons, and Fulton	80, 993, 275	123, 717, 000	122, 018, 000	35, 783, 005	60, 200, 000	51, 850, 000
Weyerhaeuser & Denkmann, Renwick, Shaw & Crosset, and 10 other firms at Rock Island, Davenport, and Moline	80, 565, 185	104, 350, 000	74, 550, 000	33, 150, 000	52, 500, 000	33, 440, 000
Hershey Lumber Company, P. M. Musser & Co., S. & J. C. Atlee, and 9 other firms below Davenport	63, 351, 880	91, 400, 000	87, 375, 000	25, 773, 030	45, 760, 000	33, 345, 000
Schulenberg, Boeckler & Co., Hersey, Bean & Brown, and 10 other firms on the Saint Croix	53, 341, 030	66, 793, 000	75, 520, 000	7, 450, 000	26, 700, 000	23, 970, 000
Eau Claire Lumber Company, Union Lumber Company, Daniel Shaw & Co., and 17 other firms on the Chippewa	157, 046, 678	255, 866, 999	264, 077, 000	2, 150, 000	18, 200, 000	26, 975, 000
La Crosse Lumber Company, C. S. Coleman, John Paul, and 10 other firms on the Black	49, 250, 000	70, 852, 747	62, 000, 000	19, 950, 000	23, 200, 000	17, 750, 000
Total for Mississippi and tributaries (124 firms)	708, 977, 132	1,009,729,746	931, 709, 000	227, 359, 383	389, 685, 000	317, 518, 000

NOTE.—The total day-sawing capacity of the mills of the firms above mentioned is 1,263,500,000 feet of lumber per season.

In order to show the entire lumber business of the Upper Mississippi Valley for the past three seasons, I give the following:

Summary.

Locality.	Lumber manufactured.		
	1877.	1876.	1875.
	Feet.	*Feet.*	*Feet.*
Main river	456, 840, 424	629, 967, 000	555, 397, 000
Saint Croix	53, 341, 030	66, 793, 000	75, 520, 000
Chippewa	157, 046, 678	255, 866, 999	264, 077, 000
Black	49, 250, 000	70, 852, 747	62, 000, 000
Wisconsin	143, 523, 000	154, 700, 000	118, 000, 000
Aggregate	860, 001, 132	1, 178, 179, 146	1, 074, 994, 000

Receipts at Saint Louis from Upper Mississippi River.

	1877.	1876.
White-pine lumber and logs ..... feet	163, 304, 150	165, 889, 702
Shingles ..... pieces	64, 919, 000	59, 981, 000
Laths ..... pieces	15, 973, 200	15, 380, 750
Pickets ..... pieces	.....	6, 803, 000

STEAMBOATS AND FREIGHT.

The principal steamboat-lines on the Upper Mississippi, above Saint Louis, are the Keokuk Northern line, and the Diamond Jo. line. Besides these there are numerous independent boats carrying freight and passengers. I submit below a statement of the two principal lines above mentioned; of the amount of freight, including coal, ice, &c., carried by the independent boats, I have insufficient data to make a reliable estimate, although the amount was very large, probably about one-third as much as the two main lines combined.

Statement of the two principal steamboat lines, Upper Mississippi River.

Name.	1877.		1876.	
	Freight.	Passengers.	Freight.	Passengers.
	Tons.		*Tons.*	
Keokuk N. L. Co	204, 098	84, 981	258, 244	.....
Diamond Jo	75, 000	18, 365	93, 676	6, 824
Total	279, 098	103, 346	351, 920	

Statement of amount of freight received at and shipped from Saint Louis by the Upper Mississippi River for six years.

	1877.	1876.	1875.	1874.	1873.	1872.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
Received	136, 715	224, 860	198, 100	231, 060	281, 175	242, 384
Shipped	68, 565	93, 360	96, 225	95, 800	61, 966	55, 235
Total carried	205, 280	318, 220	294, 325	326, 860	343, 141	297, 619

Table showing the aggregate receipts at Saint Louis from the Upper Mississippi River in 1877.

Articles.	Designation.	Quantity.	Articles.	Designation.	Quantity.
Apples	Barrels	27,944	Iron and steel	Tons	2,096
Barley	Sacks	66,490	Lard	Pounds	615,305
Barley	Bushels	11,726	Leather	Rolls	1,043
Beans	Sacks	156	Malt	Sacks	200
Bran	Sacks	1,347	Merchandise and sundries	Packages	136,909
Butter	Packages	3,463	Oats	Sacks	162,776
Cattle	Head	10,474	Oils	Barrels	1,765
Cement	Barrels	2,721	Onions	Packages	12,416
Cheese	Boxes	1,335	Peltries	Packages	3 480
Cooperage	Flour	2,246	Pork	Barrels	9,358
Cooperage	Pork	3,945	Pork (hams)	Pounds	213,820
Cooperage	Whisky	612	Pork (meats)	Pounds	2,722,248
Cooperage	Lard, tierces	22,996	Potatoes	Packages	34,972
Cooperage	Lard, kegs	746	Rye	Sacks	4,518
Cooperage	Meat, casks	6,321	Railroad iron	Tons	210
Corn	Sacks	102,733	Seeds	Sacks	3,296
Corn-meal	Barrels	4,571	Sheep	Head	9,222
Dried fruit	Packages	837	Sugar	Barrels	155
Eggs	Packages	1,792	Tallow	Barrels	1,035
Fish	Packages	1,480	Tallow	Packages	28
Flour	Barrels	38,279	Tar and pitch	Barrels	175
Grease	Barrels	672	Tobacco	Hogsheads	1,692
Hay	Bales	59,157	Tobacco	Packages	31,683
Horses and mules	Head	3,321	Wheat	Sacks	175,589
Hemp	Bales	481	Wheat	Bushels	11,763
Hides	Pounds	398,054	Wines and liquors	Barrels	755
Hogs	Head	25,664	Wines and liquors	Boxes	324
Hops	Bales	63	Wool	Pounds	291,730

The following table affords a comparative view of the relative amount of navigation at various localities on the Upper Mississippi for the last three seasons:

Statement of steamers, barges, and rafts passing various bridges.

Locality of bridge.	Steamboats.			Barges.			Rafts.		
	1875.	1876.	1877.	1875.	1876.	1877.	1875.	1876.	1877.
Dubuque	2,771	2,647	1,801	776	1,339	816	1,136	1,090	642
Clinton	2,471	2,925	2,174	600	455	633	930	*261	*352
Rock Island	1,830	1,976	1,560	630	696	790	618	627	413
Burlington	1,412	1,820	1,139	495	806	431	*164	*209	*155
Keokuk	1,347	1,590	1,294	704	944	572	(†)	(†)	(†)
Quincy	.....	2,320	.....	.....	650	.....	.....	283	.....
Hannibal	1,370	1,863	1,467	447	739	585	168	183	181
Louisiana	1,496	1,793	1,331	412	638	425	109	150	106

* Partial record. † No record of rafts.

LIST OF STEAMBOAT DISASTERS AND ACCIDENTS IN THE UPPER MISSISSIPPI, BETWEEN SAINT PAUL AND THE MOUTH OF THE ILLINOIS RIVER, FOR THE SEASON OF 1877.

June 30.—Redwing burst a steam-pipe at Dallas, Ill.; 3 lives lost.

July 14.—Minneapolis and Dispatch collided below Savanna, sinking the latter; raised.

July 17.—Alex. Mitchell sunk near Oquawka, Ill., by striking a snag; raised.

July 17.—Petrel sunk on Des Moines rapids.

July 20.—Damsel sprung a leak and sunk.

September 1.—Lion struck a snag at Beef Slough and sunk; raised.

October 24.—Wyman X struck a snag near Fort Madison; boat total loss; valued at $6,000.

November 7.—Minnie Will sunk near New Boston; boat total loss; valued at $3,000.

November 8.—Alex. Mitchell struck a snag and sunk at mouth of Des Moines River; cargo damaged; raised.

CUSTOMS, REVENUE, AND TONNAGE.

That portion of the Mississippi between Saint Paul and the mouth of the Illinois River lies partly in the customs district of Minnesota and partly in the customs district

of New Orleans. Surveyors of customs are located at Burlington and Dubuque, Iowa Galena, Ill.; Saint Paul, Minn., and La Crosse, Wis.

I give also in the following statement the *total* exhibit of the port of Saint Louis, where the greater portion of the Upper Mississippi boats are registered, and which includes many of the Lower Mississippi, Missouri, and Illinois River boats.

Customs, revenue, and tonnage for fiscal year ending June 30, 1877.

Port.	Collections.	Tonnage enrolled.	Remarks.
Saint Louis, Mo	$1,422,642 93	145,454 57	444 vessels.
Burlington, Iowa	230 00	737 [illegible]	11 vessels.
Dubuque, Iowa	303 24	3,[illegible]	[illegible] vessels.
La Crosse, Wis	2,909 54	3,969 21	[illegible] vessels.
Galena, Ill	6,031 70	9,541 45	[illegible] vessels.
Saint Paul, Minn	7,440 68	2,703 53	[illegible] vessels.

INTERNAL REVENUE.

There are 10 internal-revenue districts bordering on the Mississippi River between Saint Paul and the mouth of the Illinois River. Each of these districts is composed of a large number of counties, the greater portion of which do not touch the river, but the bulk of the business receipts and revenue to the government comes from the sections bordering upon the river and tributary to its navigation and commerce.

I give below a table showing the designation of the districts touching the river between the points above named, the residence of the collector, and the amount of collections for the fiscal year ending June 30, 1877.

District.	Residence of collector.	Amount collected year ending June 30, 1877.
First Minnesota	Rochester	[illegible]
Second Minnesota	Saint Paul	154,[illegible]
Second Wisconsin	Madison	13[illegible]
Sixth Wisconsin	Sparta	[illegible]
Second Iowa	Davenport	177,[illegible]
Third Iowa	Dubuque	279,[illegible]
Fourth Iowa	Burlington	199,[illegible]
Third Illinois	Mount Carroll	1,03[illegible]
Fourth Illinois	Quincy	1,32[illegible]
Fourth Missouri	Louisiana	[illegible]
Aggregate		3,845,975 [illegible]

P 2.

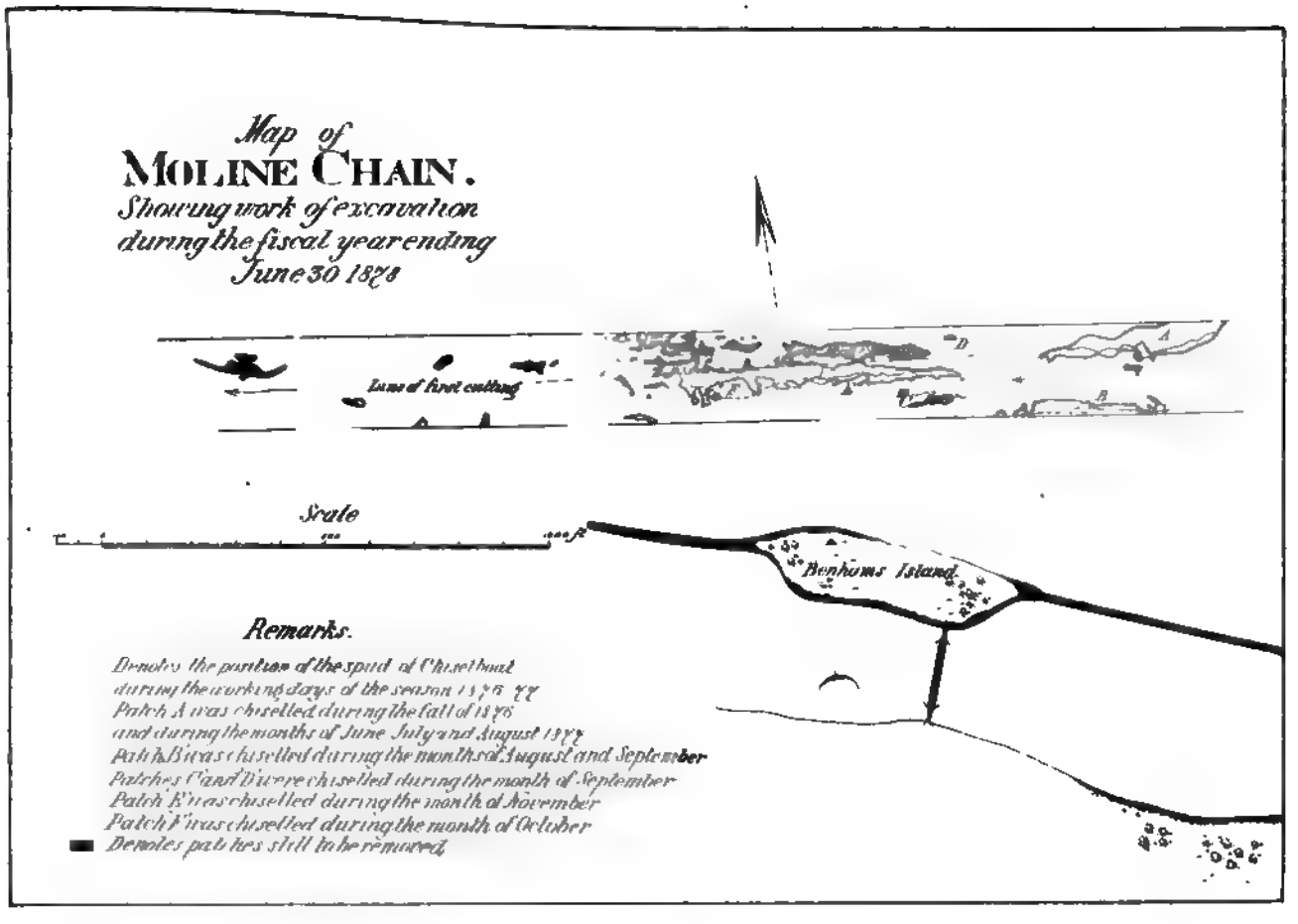
IMPROVEMENT OF ROCK ISLAND RAPIDS, MISSISSIPPI RIVER.

Col. J. N. Macomb, Corps of Engineers, was in charge of this work November 15, 1877, when he was relieved by Maj. F. U. Farquhar, Corps of Engineers.

One thousand and fifty-two cubic yards of rock were chiseled at the foot of Moline Chain, leaving 1,207 cubic yards still to be chiseled and 2,505 cubic yards to be dredged. The work was done by means of a chisel-boat hired by the month and manned by hired labor.

The report of Mr. E. F. Hoffmann, assistant engineer, is hereto appended, which gives all the details of the season's work.

During the fiscal year ending June 30, 1879, it is proposed: 1st, to finish the work at Moline Chain; 2d, to remove a small patch of rock, containing 350 cubic yards, from the narrow Cabin Passage on the Saint Louis Chain; and 3d, to make in the autumn a careful survey of the


Map of
MOLINE CHAIN.
Showing work of excavation
during the fiscal year ending
June 30 1878
Line of first cutting
Scale
Benhams Island
Remarks.
Denotes the position of the spud of Chisel boat
during the working days of the season 1877 78
Patch A was chisselled during the fall of 1876
and during the months of June July and August 1878
Patch B was chisselled during the months of August and September
Patches C and D were chisselled during the month of September
Patch E was chisselled during the month of November
Patch F was chisselled during the month of October
Denotes patches still to be removed

rapids, using the Hoffmann sounding-machine and rake to determine if any loose rock or bowlders have been brought into the improved channels by ice.

The sum of $20,000 should be appropriated for the fiscal year ending June 30, 1880, for constructing a system of channel-marks and cleaning the improved channels of any loose rock or bowlders that may be found in them by the proposed survey. This will finally complete this work.

Money statement.

July 1, 1877, amount available	$14,762 87	
Amount appropriated by act approved June 18, 1878	30,000 00	
		$44,762 87
July 1, 1878, amount expended during fiscal year	11,505 00	
July 1, 1878, outstanding liabilities	406 50	
		11,911 50
July 1, 1878, amount available		32,851 37
Amount (estimated) required for completion of existing project		20,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880		20,000 00

REPORT OF MR. E. F. HOFFMANN, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Rock Island, Ill., June 30, 1878.

MAJOR: I have the honor to submit my annual report of operations for the "improvement of the Rock Island Rapids of the Mississippi River" during the fiscal year ending June 30, 1878.

In my last annual report the excavation of 143.3 cubic yards of rock at the foot of Moline Chain was given for the month of June, 1877. The chisel-boat, with a picked crew, worked until November 30, with very good results.

July, 1877, exhibited 238 cubic yards of rock broken; August, 1877, exhibited 204 cubic yards; September, 1877, exhibited 224 cubic yards; October, 1877, exhibited 213 cubic yards; November, 1877, exhibited 173 cubic yards; total, 1,052 cubic yards.

Of the whole amount of 2,505 cubic yards to be broken at Moline Chain, there have already been disposed of 1,298 cubic yards, so that 1,207 cubic yards remain to be worked during the fiscal year ending June 30, 1879. The exhibit of work done by the chisel-boat is a very favorable one. Experience has shown that the breaking of rock by the chisel-boat on the different formations of limestone varied in daily amount from 5.5 cubic yards to 10.4. In but one instance, at Sycamore Chain, where the rocky bottom of the river consists of soft magnesian limestone, the breaking of rock reached as high as 14 cubic yards for a few days. During the present season 9.2 cubic yards were daily disposed of by the chisel, a result which can be called a good one, inasmuch as the rock at the foot of Moline Chain is a very hard white limestone, mixed with silicate.

As there have been removed 1,195, or, in round numbers, 1,200 cubic yards by the chisel-boat during the months June to November, 1877, inclusive, and as the data obtained from the office exhibit a disbursement of about $9,500 during that time, I am able to submit a comparison between the system of doing the work at Moline Chain by hired labor and machinery and by the system of inviting bids and letting the work to the lowest bidder. It may be stated in advance that bids for similar work on other less dangerous chains have at different times reached the high prices of $18.20 and $24 per cubic yard, and at the Moline Chain therefore an assumed price of $20 per cubic yard is not taken at random in the within table of comparison.

Apart from the *economy* of doing the work by hired labor and machinery, as seen by the table, it may be stated that the quality of work done by this system is superior. Contractors are anxious to push the work, and, notwithstanding the strictest surveillance, pieces of rock remain unbroken and cause serious trouble at times.

In the system of hired labor the *thorough* execution of the work is paramount.

Table exhibiting a comparison between the cost of excavating rock at Moline Chain by hired labor and by contract.

Contract work.		Hired labor and machinery.	
1,200 cubic yards, at assumed price of $20 per yard	$24,000	1,200 cubic yards, including engineering and contingencies	$9,500
Add 6 months' expenses for engineering and contingencies, at $650 per month	3,900	Add 40 days' hire of dredge, at $100 per day	4,000
	27,900		13,500
Price per cubic yard, $23.25.		Price per cubic yard, $11.25.	

The work of the chisel-boat at the foot of Moline Chain was often interfered with by passing steamers and rafts.

The narrowness of the channel between the rock patches to be worked at and the margin of the channel made it necessary to raise the side anchors and swing out of the way. There were two collisions between rafts and the chisel-boat, one in July and one in September. In both cases the chisel-boat was carried downstream one-half mile, but no loss of life or other than small damage to rope was experienced. I take pleasure at this point to recommend Mr. C. H. Benck, assistant engineer, to your favorable consideration, as well as the men constituting the crew of the chisel-boat. The faithful services of Mr. Benck, who superintended the operations of the chisel-boat, deserve honorable mention, as by his care and foresight disastrous accidents have been avoided. I inclose a sketch in relation to the work of the chisel-boat at the foot of Moline Chain, which explains itself.

In the office the following maps were drawn: 28 maps representing the different chains of the rapids before and after improvement were reduced from the large hydrographic sheets of the rapids survey; 1 map representing on a reduced scale the rapids from the head to the foot before and after improvement; 3 maps showing the pit of coffer-dams at Moline and Smith's Chains and the method of subaqueous blasting by the use of tripods; 1 map exhibiting a longitudinal section through the natural channel, and through the different cuts at the chains from the head to the foot of the rapids; 7 maps showing cross-sections at the 7 different chains; 1 map containing levels of surface of water at low-water of 1864 and high-water of 1870; 1 map exhibiting the method of sounding during the early years of the improvement.

The above enumerated maps are drawn in India ink for the purpose of being later multiplied by photolithographic process to serve for illustrating the proposed history of the improvement. Material has been collected from the records of the office and the history begun. Fair progress has been made in this work.

Besides these maps, numerous other maps and copies of maps have been made or reduced and drawn.

Considerable time was devoted to the collation and preparation of additional evidence from the office records for use in the case of C. G. Case & Co. vs. The United States, now pending in the Supreme Court.

Very respectfully, your most obedient servant,

E. F. HOFFMANN,
Assistant Engineer.

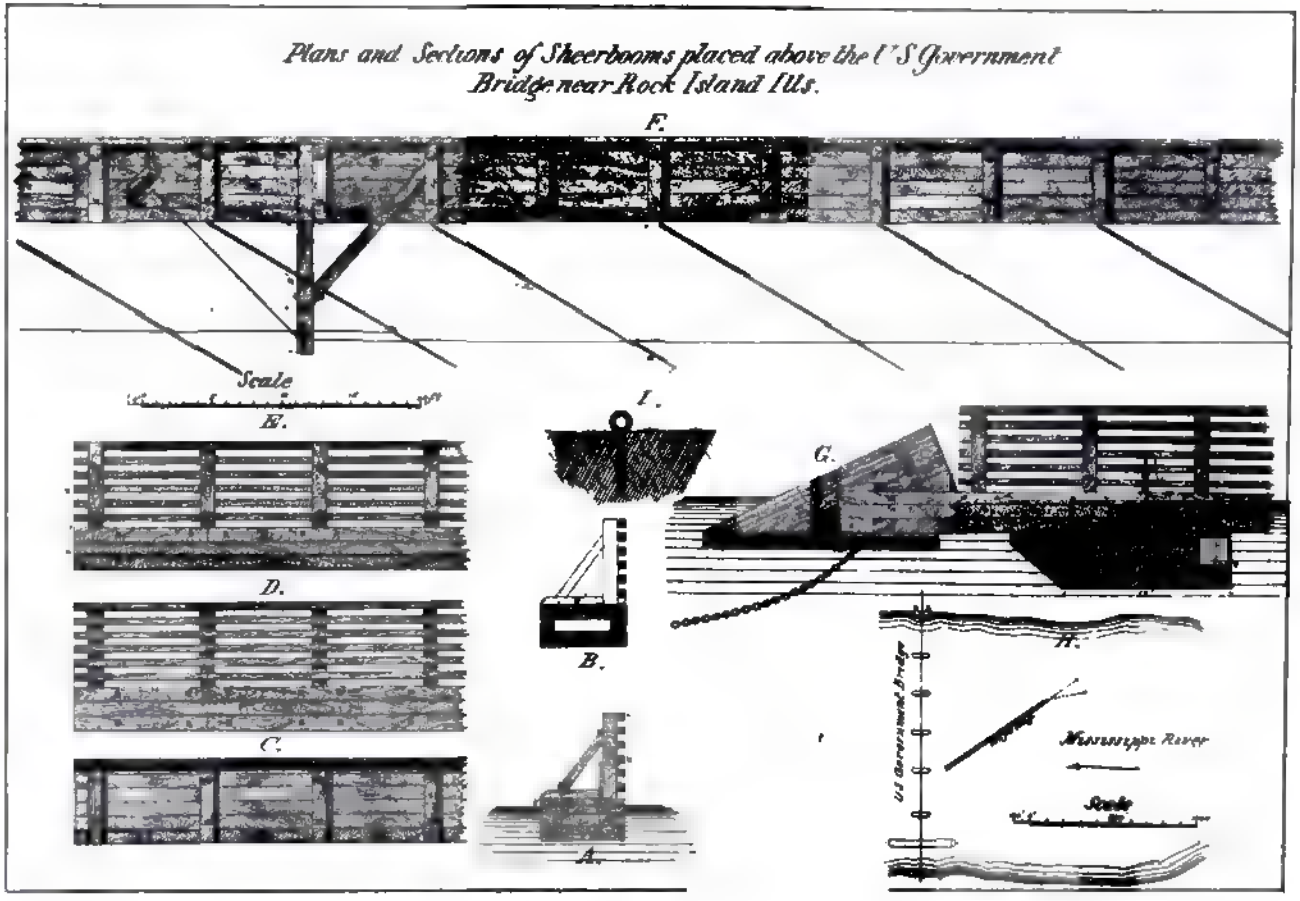
Maj. F. U. FARQUHAR,
Corps of Engineers, U. S. A.

P 3.

PROTECTING PIERS AT ROCK ISLAND BRIDGE BY MEANS OF SHEER-BOOMS.

This work was under the charge of Col. J. N. Macomb, Corps of Engineers, until November 15, 1877, when he was relieved by Maj. F. U. Farquhar, Corps of Engineers.

Under a contract made with the Eau Claire Lumber Company (a part proprietor of the Pond sheer-boom), two booms were constructed, one 750 feet in length, which was furnished with rudders to work it, called a Pond sheer-boom, and one without rudders, 400 feet in length.


Plans and Sections of Sheerbooms placed above the U S Government Bridge near Rock Island Ills.
F.
Scale
E.
D.
C.
I.
B.
A.
G.
H.
Mississippi River
Rock

The booms should have been in place last fall, but the very low stage of water in the Chippewa River prevented the booms from being floated down from Eau Claire, where they were built.

The booms arrived at the bridge on the 19th of May, but it was not until June 25 that everything was in working order.

There has not yet time enough elapsed to fairly test the value of the rudder-boom, but from the few experiments made it gives promise of being a very useful appendage to the bridge.

The accompanying drawing shows the details of the construction. The sheer-boom without rudders is in every other respect like the one furnished with them. The cut-water at the head of the boom was put on after the boom was in place, as the square end of the boom would be destroyed if struck by a raft without it.

On Fig. H is shown the location of the booms. Fig. F shows the rudder-boom in plan. Fig. E is a rear elevation, Fig. D a front elevation, and Fig. C a plan of the boom without rudders. Figs. A, B are sections of the same. Fig. I shows one of the anchoring-bolts, of which there are two. Fig. G shows the cut-water at head of rudder-boom and the pontoon. This latter is generally full of water, but it can be pumped out when at high stages of water there is a great strain on the anchoring-chains, which might pull the head of the boom under.

The rudder-boom is furnished with 44 rudders, 16 feet apart, and operated by wire rope and 9 crabs. This enables one man to operate the boom with great ease. The rudder-boom is anchored to the bolts by means of a 1-inch iron chain, 420 feet long, which passes from one anchor-bolt up to and through an iron hawse-pipe on the head of the boom, and then passes around two iron bolts at the second stanchion, thence back through another hawse-pipe to the other anchor-bolt.

The other boom, which hangs against the rocky shore of the island just above the south abutment, is attached to a crib which is furnished with a cut-water.

All the lumber of which the booms are constructed is pine, except the rudders, which are of oak.

The rudders are 20 feet long, 3 feet wide, and tapering in thickness from 3 inches at the hinge to 1½ inches at the outer end.

Money statement.

July 1, 1877, amount available		$15,000 00
July 1, 1878, amount expended during fiscal year	$11,453 58	
July 1, 1878, outstanding liabilities	264 37	
		11,717 95
July 1, 1878, amount available		3,282 05

P 4.

IMPROVEMENT OF HARBOR AT FORT MADISON, IOWA.

In charge of Col. J. N. Macomb, Corps of Engineers, until November 15, 1877, when he was relieved by Maj. F. U. Farquhar, Corps of Engineers. The work on this improvement consisted in closing Niota Chute, opposite Fort Madison, which diverted about two-fifths of the water from the main channel. The plan of construction was the same as at Rush Chute.

The dam was located near the head of Island 392, and was placed as

near as might be at right angles to the thread of the current. At the close of the season's work, October 2, 1877, the dam was in most places 1 foot above low-water.

Amount of rock	3,266 yards.
Amount of brush	3,853 yards.
Total in dam	7,119 yards.
Linear feet of dam	1,100

Average cost of dam and shore protections, $1.27 per yard.
Average cost of dam proper, $1.16 per yard.

To the local inspector, Mr. R. P. Lowe, much credit is due for skillful management of the work.

It is proposed during the present season, with the funds available, to finish the dam and shore protections, for which about 2,500 cubic yards of rock will be required. Further examinations will be necessary in order to project such additional work as may be needed.

ABSTRACT OF APPROPRIATIONS MADE FOR IMPROVING HARBOR OF FORT MADISON, IOWA.

By act approved August 14, 1876	$10,000 00
By act approved June 18, 1878	8,000 00
Total	18,000 00
Original estimate for existing project	30,186 87
Remaining to be appropriated	12,186 87

The work was done by hired labor and the stone bought by contract. Abstract of proposals are herewith attached.

Money statement.

July 1, 1877, amount available	$9,636 57	
Amount appropriated by act approved June 18, 1878	8,000 00	
		$17,636 57
July 1, 1878, amount expended during fiscal year	9,341 83	
July 1, 1878, outstanding liabilities	257 75	
		9,599 58
July 1, 1878, amount available		8,036 99
Amount (estimated) required for completion of existing project		12,186 87
Amount that can be profitably expended in fiscal year ending June 30, 1880		12,186 87

Abstract of bids received by Col. J. N. Macomb, Corps of Engineers, U. S. A., at Rock Island, Ill., June 29, 1877, for improvement of harbor of Fort Madison, Iowa.

Number.	Name of bidder.	Address.	Names of guarantors.	For furnishing and delivering rock at or near the northeast end of the proposed dam.	For furnishing and delivering rock in dam.	For furnishing and delivering rock on east shore of Niota Chute, about one mile below proposed dam.	For furnishing and delivering rock on Island No. 390, at the point where the proposed dike strikes said island.	For furnishing and delivering rock on Island No. 392, at the point where the proposed dam is to begin.	For furnishing and delivering rock on barge where the proposed dam is being built, and let stone be used from the barge.	For furnishing and delivering rock within one mile from head of Island No. 392.
				Per cub. yd.	*Per cub. yd.*	*Per cub. yd.*	*Per cub. yd.*	*Per cub. yd.*	*Per cub. yd.*	*Per cub. yd.*
1	Wells, Timberman & Co	Keokuk, Iowa	Smith Hamill Samuel E. Cary	$1 50	$1 75	.....	.....	.....	.....	.....
2	Charles Doerr	Ft. Madison, Iowa	D. F. Brown Ed. Hoffmann	.....	.....	$1 35	$1 60	.....	.....	.....
3	A. M. Hutchinson	Keokuk, Iowa	J. H. Langley Lon. Bryson	.....	.....	.....	.....	$1 18	$1 25	*$0 82
4	H. S. Brown	Hamilton, Ill	George M. Case Willard Johnson	.....	.....	.....	.....	.....	.....	1 15
5	Samuel S. Sample	Keokuk, Iowa	B. F. Hambleton W. S. Sample	.....	.....	.....	.....	1 13	.....	85

* Contract awarded.

P 5.

IMPROVEMENT OF RUSH CHUTE AND HARBOR AT BURLINGTON, IOWA.

Col. J. N. Macomb, Corps of Engineers, was in charge until November 15, 1877, when he was relieved by Maj. F. U. Farquhar, Corps of Engineers. The work on this improvement consisted in building a dam between Rush Island (No. 374) and Otter Island (No. 373) for forcing more water into the regular channel through Rush Chute. The location of the dam was near the head of Rush Island and nearly at right angles to the current.

The foundation and apron is of brush, made into fascines 1 foot thick and 12 feet long, the body of the dam being of loose rock. The head of Rush Island was protected by riprap, and the same shore protection, with a layer of fascines at the toe of the slope, extended 100 feet below the axis of the dam on Rush Island. At the Otter Island end the bank was riprapped 50 feet above and 100 feet below the axis of the dam.

All the work was done by hired labor, except the furnishing of the rock, which was bought by contract.

At the close of operations, October 27, 1877, the dam averaged 5 feet in height clear across, bringing it up to grade in some places and in others leaving a height of 7 feet to be completed. The brush foundation and apron were complete.

	Cubic yards.
Rock in place	1,463.8
Brush	3,285.5
Total	4,749.3

The local inspector, Mr. F. S. Eastman, deserves credit for energetic and faithful performance of his duties.

It is proposed during the present season, with the available funds, to finish the dam at the head of Rush Chute.

Some other work may be necessary below the head of Rush Chute, but an examination must be made before the work is commenced. Some 2,839 cubic yards of rock will be needed to finish the dam.

ABSTRACT OF APPROPRIATIONS MADE FOR IMPROVEMENT OF RUSH CHUTE AND HARBOR OF BURLINGTON, IOWA.

By act approved August 14, 1876	$10,000 00
By act approved June 18, 1878	10,000 00
Total	20,000 00
Original estimate for existing project	35,221 70
Remaining to be appropriated	15,221 70

Money statement.

July 1, 1877, amount available	$9,927 79	
Amount appropriated by act approved June 18, 1878	10,000 00	
		$19,927 79
July 1, 1878, amount expended during fiscal year	9,793 78	
July 1, 1878, outstanding liabilities	100 00	
		9,893 78
July 1, 1878, amount available		10,034 01
Amount (estimated) required for completion of existing project		15,221 70
Amount that can be profitably expended in fiscal year ending June 30, 1880		15,221 70

COMMERCIAL STATISTICS.

River commerce at Burlington, Iowa, for 1877.

Designation.	Quantity.	Value.
Lumber.....feet..	95,009,000	$1,615,000
Shingles.....	63,000,000	189,000
Lath.....	10,000,000	27,000
Sash, doors, &c.....	.....	50,000
Wood.....cords..	10,000	35,000
Coal.....tons..	12,000	35,000
Brick.....	300,000	18,000
Sand.....tons..	12,000	8,000
Merchandise of various kinds.....	.....	1,265,000
Total.....	.....	3,242,000

Abstract of bids received by Col. J. N. Macomb, Corps of Engineers, U. S. A., at Rock Island, Ill., on the 25th July, 1877, for improving Rush Chute and harbor of Burlington, Iowa.

Number.	Names and residences of bidders.	Names of guarantors.	Furnishing and delivering rock in dam.	Furnishing and delivering rock at foot of High street, Burlington.	Furnishing and delivering rock on river bank 5 miles below Rush Chute.	Furnishing and delivering rock in city of Burlington, not lower than foot of Locust street.	Furnishing and delivering rock on bank of river within 30 miles of Rush Island.	Furnishing and delivering rock on river bank in Burlington, between Valley and High streets.	Furnishing and delivering rock on barges at wharf.	Furnishing and delivering rock on river bank 25 miles below head of Rush Isl'nd.	Furnishing and delivering rock at head of Rush Isl'd or foot of Otter Island.	Furnishing and delivering rock 2 miles below Rush Chute.	Furnishing and delivering rock 3 miles from head of Rush Island.
			Per cu. yd.	*Per cu. yd.*	*Per cu. yd.*	*Per cu. yd.*	*Per cu. yd.*	*Per cu. yd.*	*Per cu. yd.*	*Per cu. yd.*	*Per cu. yd.*	*Per cu. yd.*	*Per cu. yd.*
1	John Brady, Burlington, Iowa.	H. E. Hunt, W. W. Wightman.	$1 80	$1 19	.....	.....	.....	.....	.....	.....	.....	.....	.....
2	*John Hussell, Burlington, Iowa.	Isaac Devin, Geo. Bisch	.....	.....	$0 77½	.....	.....	.....	.....	.....	.....	.....	.....
3	C. Mark Cole, Harman, Ohio.	C. M. Cole, W. W. McCoy	1 50	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
4	W. F. Hoyt & Co., Burlington, Iowa.	J. F. Copt, Jos. Johnston	1 73	.....	.....	$0 98	.....	.....	.....	.....	.....	.....	.....
5	J. C. Kille, Keokuk, Iowa.	Frank Allen, J. B. Kissick.	1 70	.....	.....	.....	$0 83	.....	.....	.....	.....	.....	.....
6	James Kelley, Burlington, Iowa.	Henry Miller, jr., John Loftus.	.....	.....	.....	.....	.....	$1 00	$1 15	.....	.....	.....	.....
7	Samuel S. Sample, Keokuk, Iowa.	Frank Hambleton, Wm. S. Sample.	1 43	.....	.....	.....	.....	.....	.....	$0 82	$1 42	.....	.....
8	Mathias Hughes & Co., Burlington, Iowa.	J. C. Foley, Luke Hughes, sr.	.....	.....	.....	.....	.....	.....	.....	.....	.....	$1 72½	.....
9	A. J. Swindler & Co., Burlington, Iowa.	C. N. Brantigan, W. McO. Haresworth.	2 25	.....	.....	.....	.....	.....	.....	.....	.....	.....	$1 25

*Contract awarded.

P 6.

REMOVAL OF BAR IN THE MISSISSIPPI RIVER OPPOSITE DUBUQUE, IOWA.

Col. J. N. Macomb, Corps of Engineers, was in charge until November 15, 1877, when he was relieved by Maj. F. U. Farquhar, Corps of Engineers.

The work during the fiscal year consisted in dredging 39,261 cubic yards of sand of the point of the bar that extends from the Barney Cut in the levee, down-stream, to below the steamboat landing. The point of the bar was removed as far up as opposite the middle of the wharf-boat. The dredging was done by contract by Mr. George Williams, of Keokuk, who was the only bidder who could begin the work in a reasonable time. The abstract of proposals received is hereto appended.

The dredging should be continued up-stream so as to give steamboats an easy access to the landing. This would require a further dredging of 84,128 cubic yards, which will cost $23,135.20.

Seventh Street Slough and New Barney Cut should be closed. No estimate is made for closing the cuts, as it would seem that such work should be done by the city of Dubuque rather than by the United States. With the funds available the dredging will be continued.

Not less than $13,125.20 should be appropriated for the fiscal year ending June 30, 1880.

Commercial statistics are hereto appended.

Dubuque is in the customs-district of New Orleans, La.

Money statement.

July 1, 1877, amount available	$14,416 82	
Amount appropriated by act approved June 18, 1878	10,000 00	
		$24,416 82
July 1, 1878, amount expended during fiscal year		14,383 65
JuIy 1, 1878, amount available		10,033 17
Amount (estimated) required for completion of existing project		13,125 20
Amount that can be profitably expended in fiscal year ending June 30, 1880		13,125 20

COMMERCIAL STATISTICS.

Receipts by river.

Lumber	75,000,000 feet.
Hogs (live and dressed)	4,060,000 pounds.
Oats	12,700,000 pounds.
Corn	1,470,000 pounds.
Wheat	366,420 pounds.
Flour	112,000 pounds.
Butter	110,000 pounds.
Green hides	381 packages.
Lead	594,110 pounds.
Salt	18,000 barrels.
Cement	1,700 barrels.
Staves	500,000
Horses	412 head.
Cattle	4,300 head.
Coal	14,400,000 pounds.
Merchandise, including iron, nails, glass, oils, cordage, wagon material, and goods of every description	51,000 tons.
Number of passengers landed	14,280
Number of steamboat landings	914

Shipments by river.

Oats	28.250.[illegible] pounds.
Wheat	3.412.[illegible] pounds.
Corn	1.117.312 pounds.
Barley	31[illegible].[illegible] pounds.
Butter	[illegible].170 pounds.
Pork	2.[illegible].547 pounds.
Lard	2.2[illegible].132 pounds.
Merchandise	2.1[illegible].[illegible] pounds.
Cordage	121.[illegible] pounds.
Salt	13.[illegible] barrels.
Cement	1.110 barrels.
Lumber	6[illegible].[illegible] feet.
Horses	1.1[illegible] head.
Cattle	212 head.
Number of passengers	9.7[illegible]

Abstract of bids received by Col. J. N. Macomb, Corps of Engineers, U. S. A., at Rock Island, Ill., on August 7, 1877, for removal of a bar in Mississippi River opposite Dubuque, Iowa.

Number.	Name of bidder.	Residence.	Names of guarantors.	For earth and sand excavation (dredging), per cubic yard.	For working by the hour one or more dredges manned and equipped complete.
1	Williams & Upham ..	Houghton, Mich..	Samuel L. Smith, William Harris	$0 25	$12 00
2	George B. Woodworth.	Dubuque, Iowa ..	William W. Woodworth, Charles A. Reed.	25	15 00
3	George Williams*	Keokuk, Iowa	H. S. Brown, Jos. W. Bishop....	27	12 00

*Contract awarded.

P 7.

IMPROVEMENT OF THE MISSISSIPPI RIVER FROM THE BRIDGE OF THE CHICAGO, MILWAUKEE, AND SAINT PAUL RAILROAD, ABOVE LA CROSSE, WISCONSIN, TO THE MOUTH OF ROOT RIVER, BELOW SAID CITY.

No work was done during the last fiscal year. The work to be done here consists in closing the chute on both sides of Bates Island and protecting the head of Grand Island.

This work will be commenced as soon as contracts can be made after due advertising for proposals.

The amount, $12,500, appropriated by act approved June 18, 1878, will complete the work.

Money statement.

Amount appropriated by act approved June 18, 1878	$12,500 00
July 1, 1878, amount available	12,500 00

CONDITION OF THE CHANNEL OF THE MISSISSIPPI RIVER AT LA CROSSE, WISCONSIN.

UNITED STATES ENGINEER'S OFFICE,
Rock Island, Ill., 18th August, 1877.

GENERAL: I have the honor to transmit herewith the report of the Board of Engineers constituted by special orders No. 1, dated War

Department, Adjutant-General's Office, Washington, D. C., January 4, 1875, and reconvened by special orders No. 93, dated headquarters Corps of Engineers, Washington, D. C., August 11, 1877, to consider and report upon condition of the channel of the river at La Crosse, Wis.

I remain, very respectfully, your most obedient servant,

J. N. MACOMB,
Colonel of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers U. S. A.

[First indorsement.]

OFFICE OF CHIEF OF ENGINEERS,
August 29, 1877.

Respectfully submitted for the information of the honorable the Secretary of War.

In the opinion of the Chief of Engineers the report seems reasonable and the suggestions or recommendations judicious.

By direction of Brigadier-General Humphreys, and in his absence.

GEORGE H. ELLIOT,
Major of Engineers.

REPORT OF BOARD OF ENGINEERS.

LA CROSSE, WIS.,
August 16, 1877.

GENERAL: The Board of Engineers constituted by special orders No. 1, dated War Department, Adjutant-General's Office, Washington D. C., January 4, 1875, and reconvened by special orders No. 93, dated headquarters Corps of Engineers, Washington, D. C., August 11, 1877, met at La Crosse, Wis., on the 15th instant, all the members being present.

The order in question directs the Board—

To examine and report upon the condition of the channel-way of the river opposite that city [La Crosse], the cause of the changes that have taken place or are now taking place in the bed of the stream, and to recommend such works and measures by the United States, if any, as may be considered proper and expedient to arrest the shoaling and restore the channel to its former position.

The first duty prescribed in the above instructions is to report upon the present condition of the channel-way opposite La Crosse.

The channel of the Mississippi along the La Crosse landing is in excellent condition, and the "Grand Crossing," a bar just below the city that has usually been very troublesome, has now a greater depth of water than many other bars above and below.

The part of the river in this vicinity about whose condition the citizens of La Crosse were apprehensive extends upstream from the mouth of the Black River to the foot of Minnesota Island, a distance of about one mile. In this section of the river there is a series of flat sand-reefs, with channels alternately close to either bank, that necessitate three square crossings of the river between the mouth of the Black and the railroad-bridge. In addition there has been an abrasion of the head of Grand or Barron's Island for a width of about 40 feet, and some of the trees and bushes thus undermined have lodged on the bar below, pointing out its shoalness with great distinctness and magnifying the bad appearance of the channel. As this piece of river is in full view of La Crosse the

depressing effect on the citizens of its ragged and unsightly appearance has naturally been very great.

In our report dated January 15, 1875, in which we prescribed the accessory works that should be built by the bridge company, we recommended that the channel east of Minnesota Island should be partially obstructed so as to make the larger flow of the river pass west of Minnesota Island where the railroad-draw is located. The railroad company did even more than we recommended, and closed the east channel entirely (except in high water) by building a dam across its head.

The natural effect of this violent change in regimen was to upset the old channel, which had developed under different conditions, and during the process of adaptation to the increased volume of water there was for a time a very ragged and variable channel. In the course of a few months, however, the enlarged volume of water had succeeded in scouring out sufficient increase of cross-section and in obtaining a fixed regimen, and now there is excellent water for a mile above the bridge where before the dam was built there was a very troublesome bar.

But this operation of developing a new and deeper channel necessitated the removal of a vast quantity of sand which was carried down stream by the currents.

The Board believe that it is this sand, thus pushed out of its former resting-place, that has been carried down in abnormal quantity and has lodged below Minnesota Island, thus causing the bars that look so formidable when viewed from La Crosse.

A careful examination induces us to believe that these bars are in a state of unstable equilibrium, and that time only is needed to enable the river currents to act on this sand and distribute it gradually down stream on shore-bars and elsewhere, where it will probably be out of the way. Experience on river improvement shows that time is an important factor, and that it is very unwise to get alarmed or discouraged if the first season's work does not immediately produce the desired result. We therefore feel reasonably confident that the bar in question will gradually improve, and that at present there is no danger in awaiting this result. We are strengthened in this belief by the fact that a careful examination failed to show any increase in the channel between Grand Island and the Minnesota shore. If this channel has not increased in cross-section, notwithstanding the injurious effect on the main channel of the vast body of sand suddenly thrust into it from above, we believe that immediate action is not now required, as under the operation of natural causes this sand is gradually drifting down and distributing itself, thereby day by day giving a freer flow through the main channel than there is now, and thus daily lessening the danger of the main current passing behind Grand Island. Notwithstanding the crookedness of the channel, we found no difficulty in getting over these bars, although the Montana could not cross the bar 2 miles above the railroad-bridge and was compelled to return to La Crosse.

The Upper Mississippi is remarkably similar to the Upper Rhine in the section between Basle and Strasbourg. Both streams are flanked by a network of secondary channels. On the Rhine the first consideration was to concentrate the whole flow in a single channel. After this was done the channel was regulated. We believe that the same general idea should control all work on the Upper Mississippi, and that, if carried into practice, the result will be as satisfactory as it has been on the improved Rhine and as it has proved when tried in a small case at the head of Minnesota Island.

With these views we hold that it is only a matter of time until all the

secondary channels on the Upper Mississippi will be closed as part of a general plan of improvement. Wherever, as at La Crosse, strong local interests add to the reasons for the closure of these channels, we believe that it should be done as soon as possible.

We see no immediate danger to La Crosse in leaving open the channels on either side of Bates Island; but rivers are proverbially variable, and as long as these channels remain open they are a standing menace to the city and to the general navigation of this part of the Mississippi. Moreover, the work of closing is a much easier matter when nature does not actively oppose the work than it is when a strong current flows through these channels.

With these views we would recommend the closing of both channels would Bates Island as soon as the interests of the government will permit.

Under all circumstances it will be a useful expenditure. As the state of the appropriations precludes work at present, we think that it is better not to prescribe the precise locations, method of construction, nor heights of these dams, as these details are properly within the province of the local engineer, who must naturally be more familiar with the peculiarities of the river in question than officers stationed at a distance.

All of which is respectfully submitted.

J. N. MACOMB,
Colonel of Engineers.
G. WEITZEL,
Major of Engineers, Bvt. Maj. Genl., U. S. A.
WM. E. MERRILL,
Major of Engineers and Bvt. Col.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

REPORT OF BOARD OF ENGINEERS ON MILWAUKEE AND SAINT PAUL RAILROAD BRIDGE AT LA CROSSE.

LA CROSSE, WIS.,
January 15, 1875.

SIR: The Board of Engineers convened by paragraph 1, Special Orders No. 1, dated War Department, Adjutant-General's Office, January 4, 1875, would respectfully submit the following report:

A copy of the act of Congress approved 22d June, 1874, which contains the conditions prescribed for the bridge at La Crosse, and which specifies the duties of the Board, is herewith attached and marked Appendix A.*

LOCATION.

It will be seen from this act that the duties of the Board in regard to location are limited to reporting whether or not a bridge can be built on the company's site so as not to interfere materially with navigation at that point. After mature deliberation the Board are of the opinion that a bridge can be so built provided certain accessory works are added, which will be indicated farther on in the report.

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*Not printed.

HEIGHT OF BRIDGE.

They are of the opinion that it will not be necessary to raise the bottom of the bridge higher than 10 feet above the highest water-mark known.

LOCATION OF PIERS.

They approve of the location of the piers indicated on the accompanying profile and map furnished by Mr. Dodge, the engineer of the company.

ACCESSORY WORKS.

The first accessory work which the Board would recommend is the partial obstruction of the channel east of Minnesota Island. They would recommend that at a point about 500 feet, more or less, below the head of Minnesota Island (the exact location to be left to the local engineer officer), the banks should be paved and the bottom partially covered with stone so as to reduce the flow through this channel and to prevent the possible danger of the main volume of the Mississippi leaving the western channel, which will be prepared to accommodate navigation, for the eastern channel, which will not be so prepared. They also think that it would be advantageous to reduce the cross-section of the water-way at the place where the bridge crosses the eastern channel to what it will be at the point near the head of the channel where it is to be partly obstructed.

The Board also think that it would be judicious to close the three openings leading into the French Slough, but they do not consider this work as important, and therefore would recommend that it be left to the discretion of the railroad company.

The western or Minnesota shore should be graded to a gentle slope of 45° or less, and paved with stone with a footing of riprap for a distance of about 1,000 feet above the bridge and the same distance below it, so as to maintain the shore-line and preserve a regular approach to the draw openings. The exact length of shore above the bridge which requires revetment must be determined by the action of the current. The protection should extend above the highest point at which any abrading action is apparent.

The channel between Bates Island and the Minnesota shore should be closed by a dam of piles, brush, and stone, or its equivalent, extending to a height of 6 feet above low water, with shore revetments extending 200 feet below each end of the dam, so as to prevent it from being turned by the scour of the overfall. The reason why the Board think that this work should be done by the bridge company is that the position of the draw-span is such that rafts will be compelled to pass through the draw in high water and at such stages they will naturally float so near the head of this channel that unless the current in it is reduced they will be in danger of being drawn through it. It has been stated to the Board by lumbermen that the navigation of this channel is difficult for rafts, and that all rafts desire to stop at La Crosse for supplies or to be made up into larger rafts. As the construction of the bridge will prevent rafts from hugging the west shore of Minnesota Island, by which course they could avoid the danger of being drawn into this objectionable channel, it seems not unreasonable to call upon the railroad company to remedy this trouble which will follow the erection of their bridge.

It will likewise be necessary to make a high-water levee from the solid

embankment of the railroad-track to a point about 100 feet below the site of the dam across the Bates Island Channel, so as to cut off the draught over the banks in time of high water.

This levee would probably be 6 feet in height and 3,500 feet in length. It could be prevented from washing by being paved, sodded, or planted with willows.

These are all the accessory works that seem to be required in order to make navigation secure at the proposed site; but the Board, bearing in mind the uncertainty of all river-work, would recommend that this subject be put under the charge of the local engineer officer to recommend such additions or changes as from time to time may seem to be necessary.

There are certain other conditions that should likewise be prescribed.

RIPRAP.

No riprap around any of the piers in the main or Minnesota Channel should rise higher than 3 feet below low water mark or have a greater width on top than 3 feet.

PIVOT-GUARD.

The pivot-pier should be provided with the usual extension up and down stream for the protection of the draw when open.

SNUBBING-POSTS.

To enable boats to tie up to the bank in case of accidents to boat or to draw, 8 stout snubbing-posts should be provided along the shore above the bridge, commencing 150 feet above and extending to a distance of 500 feet above, the posts being 50 feet apart.

LIGHTS.

The lights on the draw should be the same as those prescribed for the Louisiana bridge, which were as follows:

One circular red light, showing all around the horizon, should be placed over the east draw-pier at an elevation of 15 feet above the top of the bridge.

A similar light should be placed over the west draw-pier.

Three lights should be placed on the draw-span at an elevation of 15 feet above the top of the draw. They should be inclosed in square boxes with two red panes of glass and two green ones—the green glasses to show in the direction of the length of the draw and the red glasses to be at right angles to the green; the boxes should be firmly fastened in position, the lamps only being movable.

When the draw is closed five red lights will be seen from above or from below the bridge; two pairs of lights with a single light between. When the draw is open three green lights will be seen in range between the two fixed red lights on the draw-pier.

No other lights should be allowed on the bridge except such as may be required for the use of the trains.

In conclusion, the Board would state that this report has been made in strict accordance with the instructions contained in the act of Congress under which the Board was convened, but they feel it due to themselves to add that they see no reasons for changing the opinions expressed by

them in their two previous reports which were printed as Ex. Doc. No. 71, House of Representatives, Forty-second Congress, third session.

* * * * * * *

Respectfully submitted.

J. N. MACOMB,
Colonel of Engineers, President of Board.
G. WEITZEL,
Major of Engineers and Brt. Maj. Gen., U. S. A.
WM. E. MERRILL,
Major of Engineers and Brevet Colonel.

To the Honorable the SECRETARY OF WAR.

P 8.

IMPROVEMENT OF GALENA RIVER AND HARBOR AT GALENA, ILLINOIS.

No work was done, no funds being available. During the present season dredging will be commenced. The work will be done by contract after due advertising.

The estimated cost of this work (see page 290, part 1, Annual Report of Chief of Engineers, 1874) was $400,000.

The amount appropriated ($30,000) by act approved June 18, 1878, will dredge about 60,000 cubic yards of the 594,873 cubic yards estimated.

Should this work go on, at least $100,000 should be appropriated for each fiscal year, so that it could be pushed to completion.

Galena is in the customs-district of New Orleans.

Money statement.

Amount appropriated by act approved June 18, 1878	$30,000 00
July 1, 1878, amount available	30,000 00
Amount (estimated) required for completion of existing project	370,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880	100,000 00

P 9.

WIDENING AND DEEPENING THE CHANNEL OF MISSISSIPPI RIVER FROM DES MOINES RAPIDS TO THE MOUTH OF THE ILLINOIS.

No work was done during the last fiscal year.

No surveys have ever been made on this part of the river. As soon as surveys can be made of the places where obstructions to navigation exist, plans and estimates will be submitted and work commenced.

It is proposed to make a thorough survey of the river between Des Moines Rapids and the mouth of the Illinois River.

Owing to the present impossibility of definitely specifying the above work, it will be carried on by hired labor and the materials be purchased in open market.

Money statement.

Amount appropriated by act approved June 18, 1878	$100,000 00
July 1, 1878, amount available	100,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880	100,000 00

P 10.

WIDENING AND DEEPENING THE CHANNEL OF MISSISSIPPI RIVER FROM SAINT PAUL TO DES MOINES RAPIDS.

No work was done during the last fiscal year.

During the fiscal year ending June 30, 1879, it is proposed, 1st, to improve the channel at the places where the greatest obstructions to navigation exist; and, 2d, to make a survey of the river from which a complete plan for its improvement can be made.

As fast as the surveys are made, plans and estimates will be made and submitted.

A preliminary estimate for the improvement of this part of the river was made by my predecessor, Col. J. N. Macomb (see page 177, Part II, Annual Report of the Chief of Engineers for 1876), which amounted to $617,393.

Owing to the present impossibility of definitely specifying the above work, it will be carried on by hired labor and the materials be purchased in open market.

Money statement.

Amount appropriated by act approved June 18, 1878	$250,000 00
July 1, 1878, amount available	250,000 00
Amount (estimated) required for completion of existing project	367,393 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.	250,000 00

P 11.

IMPROVEMENT OF FALLS OF SAINT ANTHONY, MISSISSIPPI RIVER.

The small exploring drift (reported in my last annual report) was carried on to a point 470 feet west of the west branch of the tunnel, and the leakages of the concrete dike were taken into a drain. At all points where the drift reached the dike the concrete was found well set, the leakages being at the bottom of the upper drift, where in places the concrete filling of the drift had not adhered to the main wall below. The leakage of the wall is gradually diminishing, and in time no doubt will cease altogether.

The west slope of the apron was removed, the rock excavated, and a new apron built in the plane of the center or main slope. This involved, besides the removal of the timber of the old slope, the removal of 2,700 cubic yards of lime rock in place, 3,000 cubic yards of fallen lime rock, and 2,000 cubic yards of sand rock. The lime rock was placed to protect the toe of the apron. This remodeling of the apron cost $27,030.38.

During the past winter 450 cords of granite bowlders were placed in the deep hole at the toe of the apron on the east side.

During March and part of April, 1878, the work of extending the apron 85 feet along Hennepin Island was accomplished at a cost of $4,220.83. For this work 220,000 feet (board-measure) of lumber were taken from the coffer-dams. All the work was done by hired labor and the materials bought in open market, except the lumber for the apron and the granite bowlders, which were bought under contract reported in my last annual report. The only work that remains to be done is a wall to protect the sand rock at the west side of the apron, for which the stone is already quarried, and making some slight changes in Farnham

and Lovejoy's dam so as to exclude some water from the eastern valley of the apron. There is plenty of money available for these works, which will be prosecuted as soon as low water permits. The work has been under the local charge of Mr. J. L. Gillespie, assistant engineer, who by his intelligence and energy has contributed not a little to the success of the works designed for the "Preservation of the Falls of Saint Anthony." The faithfulness and efficiency of Mr. A. H. Weeks, overseer, and John Cullen, sub-overseer, are also worthy of much commendation.

Original estimate of Board of Engineers of 1874 (see page 385, Part I, Annual Report of Chief of Engineers for 1874) was	$419,792 00
Owing to unforeseen contingencies, this estimate was increased (see page 700, Part I, Annual Report of Chief of Engineers for 1876) to	529,726 31
There has been appropriated	345,000 00

There has been expended as follows:

Construction of dike and drains	211,089 46
Construction of rolling-dams	24,957 29
Repairs of apron	63,498 72
Repairs of coffer-dams and work necessary to repair damages made by river	26,229 22
Filling of excavations through and under limestone above dike	7,811 92
Total expenditure	333,586 61

ABSTRACT OF APPROPRIATIONS MADE FOR THE PRESERVATION OF THE FALLS OF SAINT ANTHONY.

By act approved July 11, 1870	*$50,000 00
By act approved March 3, 1871	*50,000 00
By act approved June 10, 1872	*50,000 00
By act approved March 3, 1873	*50,000 00
By act approved June 23, 1874	125,000 00
By act approved March 3, 1875	100,000 00
By act approved August 14, 1876	120,000 00
	545,000 00
Original estimate for carrying out present project	529,726 31
Remaining to be appropriated	184,726 31

Money statement.

July 1, 1877, amount available		$58,498 40
July 1, 1878, amount expended during fiscal year	$46,795 01	
July 1, 1878, outstanding liabilities	290 00	
		47,085 01
July 1, 1878, amount available		11,413 39
Amount (estimated) required for completion of existing project		184,726 31

P 12.

IMPROVEMENT OF MISSISSIPPI RIVER ABOVE THE FALLS OF SAINT ANTHONY, MINNESOTA.

During the season of 1877, 1,175 cubic yards of bowlders were removed from the bed of the river, from the head of Smilar's Rapids to Itaska, a distance of 27 miles, at a cost of $5.12 per cubic yard. In the same distance 2,771 linear feet of brush and stone dams and 1,190 linear feet

* NOTE.—These sums were used before the adoption of the present plan.

of brush and stone shore protection were constructed at a cost of $1.12 per linear foot, or 68 cents per cubic yard.

The work of removing bowlders was done with a steam-crane scow, working a grapple and a rake, and provided with a steam-drill and a hired crew.

The work of building dams was done by hired labor. The overseer was Mr. William Batson, to whom great credit is due for the faithful and energetic manner in which he carried on the work.

May 11, 1878, the crane-scow resumed work at Itaska, and has completed the work as far down as Coon Rapids, where it is now operating.

During the present season it is proposed to continue the work of removing bowlders, &c., with the crane-scow, and to repair several of the brush dams where they have been damaged by the log-drivers. This work is being done by hired labor, as it cannot be sufficiently specified for contractors.

ABSTRACT OF APPROPRIATIONS HERETOFORE MADE.

By act approved June 23, 1874*	$25,000 00
By act approved August 14, 1876	20,000 00
Total	45,000 00
Original estimate for the work between the Falls of Saint Anthony and Saint Cloud, Minn	144,667 50
Remaining to be appropriated	124,667 50

Money statement.

July 1, 1877, amount available		$16,710 02
July 1, 1878, amount expended during fiscal year	$8,387 92	
July 1, 1878, outstanding liabilities	1,494 67	
		9,882 59
July 1, 1878, amount available		6,827 43
Amount (estimated) required for completion of existing project		124,667 50
Amount that can be profitably expended in fiscal year ending June 30, 1880.		30,000 00

P 13.

CONSTRUCTION OF LOCK AND DAM ON MISSISSIPPI RIVER AT MEEKER'S ISLAND, MINNESOTA.

No work has been done here as no funds were available, because the parties holding the land-grant have not made any acceptable release as required by the act approved March 3, 1875. The State of Minnesota should annul the grant to the parties now holding the land-grant, and release the same to the United States. Should it be determined to carry on this work, a sum not less than $300,000 should be appropriated for the fiscal year ending June 30, 1880.

Money statement.

July 1, 1877, amount available	$25,000 00
July 1, 1878, amount available	25,000 00
Amount (estimated) required for completion of existing project	922,121 46
Amount that can be profitably expended in fiscal year ending June 30, 1880.	300,000 00

* Made and expended before the adoption of the present project.

P 14.

IMPROVEMENT OF MINNESOTA RIVER.

Under the contract with Messrs. Douglass & Winston Brothers (reported in my last annual report), work was commenced in July, 1877, at a point about 2½ miles below Saint Peter. When the work closed in October, 29½ miles of river had been cleared of snags and bowlders, and the banks of overhanging trees; 1,712 snags and 6 cubic yards of rock were removed from the channel of the river, and 904 overhanging trees were cut down.

There is no commerce on the river above Little Rapids at stages of low water, nor will there be until the creation of slack-water navigation. If this slack-water navigation is to be created, at least $60,000 should be appropriated to commence the lower lock at Little Rapids. The removal of snags, &c., is only a temporary relief, and is of no use until boats can pass Little Rapids at low stages of water.

ABSTRACT OF APPROPRIATIONS MADE FOR THE IMPROVEMENT OF THE MINNESOTA RIVER.

By act approved March 2, 1867	$37,500 00
By act approved July 11, 1870	10,000 00
By act approved March 3, 1871	10,000 00
By act approved June 10, 1872	10,000 00
By act approved March 3, 1873	10,000 00
By act approved June 23, 1874	*10,000 00
By act approved March 3, 1875	10,000 00
By act approved August 14, 1876	10,000 00
By act approved June 18, 1878	10,000 00
	117,500 00

Money statement.

July 1, 1877, amount available	$9,963 36	
Amount appropriated by act approved June 18, 1878	10,000 00	
		$19,963 36
July 1, 1878, amount expended during fiscal year	9,727 95	
July 1, 1878, outstanding liabilities	222 00	
		9,949 95
July 1, 1878, amount available		10,013 41
Amount (estimated) required for completion of existing project (see page 364, Part I, Annual Report of Chief of Engineers for 1875)		733,868 63
Amount that can be profitably expended, commencing lock and dam at Little Rapids, in fiscal year ending June 30, 1880		60,000 00

P 15.

IMPROVEMENT OF CHIPPEWA RIVER, WISCONSIN.

Under the contract made with Messrs. Winston, Douglass & Winston (reported in my last annual report), the west jetty was completed, its length being 4,013 feet, and the east jetty finished for a distance of 405 feet. The sand is slowly moving from the channel, and where last summer there were only a few inches in depth of water there are now more

* Used in making survey of river.

than 3 feet of water, and after the completion of the east jetty there will be a depth of water in the channel-way of at least 4 feet at low water. With the money available from the river and harbor bill approved June 18, 1878, it is proposed to finish the east pier and to build the training-dam at Flower Pot Island, which is just above the mouth of the river.

ABSTRACT OF APPROPRIATIONS FOR IMPROVING CHIPPEWA RIVER.

By act approved August 14, 1876	$10,000 00
By act approved June 18, 1878	10,000 00
	20,000 00
Original estimate for carrying out existing project	139,892 50
Remaining to be appropriated	119,892 50

Of this amount, $64,102.50 are estimated as the cost of protecting the five high sand-banks below Eau Claire. If the work of improving this river is to continue I would recommend that Congress be asked to appropriate the above amount for protecting the high banks, and an additional sum of $20,000 to continue the work of building wing-dams and jetties.

Money statement.

July 1, 1877, amount available	$9,971 82	
Amount appropriated by act approved June 18, 1878	10,000 00	
		$19,971 82
July 1, 1878, amount expended during fiscal year	9,881 18	
July 1, 1878, outstanding liabilities	50 00	
		9,931 18
July 1, 1878, amount available		10,040 64
Amount (estimated) required for completion of existing project		119,892 50
Amount that can be profitably expended in fiscal year ending June 30, 1880:		
For protecting high sand-banks	64,102 50	
For constructing wing-dams and jetties	20,000 00	
		84,102 50

P 16.

IMPROVEMENT OF RED RIVER OF THE NORTH.

Work was commenced at Moorhead about July 1, 1877. All snags, drift-piles, and overhanging trees were removed from Moorhead to a point 1 mile north of Frog Point (section 15, township 148, range 49 west, Minnesota, United States land survey), a distance of 120 miles by river, or 57 miles by land.

There were removed 217 snags, 3,996 overhanging trees, 8 drift-piles, and 1 sunken barge that was in the channel near Georgetown. The work was done by hired labor, and the overseer, Mr. Charles Wanzer, is entitled to commendation for his energy and intelligence in carrying on the work. An examination of the river was made from Frog Point to the northern boundary line, the results of which were reported in letter dated December 8, 1877.

With the funds appropriated by river and harbor bill approved June 18, 1878, it is proposed to build a dredge and to operate it with hired labor, as the amount available ($30,000) is too small to induce contractors to build a dredge in so isolated a region. The dredge will be built at Moorhead, and the work commenced upstream and continued downstream.

Should it be determined to build a lock and dam at Goose Rapids, $100,000 should be appropriated to commence the work, and $12,000 should be appropriated to continue the dredging. The steamboat line on Red River of the North carried, during season of 1877, 13,747 tons of freight.

ABSTRACT OF APPROPRIATIONS MADE FOR IMPROVING RED RIVER OF THE NORTH.

By act approved August 14, 1876		$10,000 00
By act approved June 18, 1878		30,000 00
		40,000 00

Money statement.

July 1, 1877, amount available	$8,545 37	
Amount appropriated by act approved June 18, 1878	30,000 00	
		$38,545 37
July 1, 1878, amount expended during fiscal year	6,960 66	
July 1, 1878, outstanding liabilities	20 00	
		6,980 66
July 1, 1878, amount available		31,564 71
Amount (estimated) required for completion of existing project		324,598 17
Amount that can be profitably expended in fiscal year ending June 30, 1880:		
For lock and dam at Goose Rapids	$100,000 00	
For dredging	12,000 00	
		112,000 00

SPECIAL REPORT ON EXAMINATION OF RED RIVER OF THE NORTH.

UNITED STATES ENGINEER OFFICE,
Saint Paul, December 8, 1877.

GENERAL: I have the honor to make the following report of the results of the examination of localities on the Red River of the North, between Frog Point, Dakota, and the northern boundary-line of the United States, a distance of 181½ miles, where obstructions to navigation are said to exist.

Below Frog Point the river has an average slope of .24 foot per mile. The course of the river is most tortuous, this distance by land from Frog Point to the boundary-line being 112½ miles, and the distance by river is 69 miles farther. The amount of timber on the banks of the river gradually decreases toward the north until there is none except on some points of land included in the folds of the river.

At Frog Point the river is about 250 feet wide, and at Pembina about 300 feet wide. The low-water discharge of the river at Frog Point is about 1,250 cubic feet per second, and at Pembina about 2,800.

Only two serious obstructions to navigation exist in the part of the river examined; 1st. Turtle River Bars, whose heads are about 50 miles below Frog Point and which extend down stream with intervals of deep water for a distance of 6.8 miles; and, 2d. Pelican Bars, which are 116¾ miles below Frog Point.

These bars are both formed of clay which has slid down from the banks.

This sliding down of the steep clay banks is not caused by the river undermining them, but by the clay opening in cracks under the influence of frost and drought, and afterwards these cracks catching the water during heavy rains or high water, which saturates and softens the clay which then slides into the river. In some places this sliding motion extends to more than 100 feet away from the river bank. The current of the river

is too sluggish to cut a deep channel through these clay lumps. The only way to remove these bars is by dredging. A channel 75 feet wide and 5 feet deep would be ample, and I think the sides of the cut would not wash in.

Besides these principal bars there are here and there a few mud lumps which can be easily removed, but whose exact location could not be determined except by a continuous survey of the river. Eight snags were observed in the river.

The following is the estimate for improving the river below Frog Point:

At Turtle River Bars, 68,000 cubic yards dredging, at 50 cents per cubic yard	$34,000 00
At Pelican Bars, 87,000 cubic yards dredging, at 50 cents per cubic yard	43,500 00
Removing 8 snags, at $10 each	80 00
Ten per cent for contingencies	7,758 00
Total	85,338 00

Detailed surveys of the sites of the lock and dam proposed in my report of March 4, 1874, were made, together with the necessary borings to determine the character of the underlying clay.

The estimates of the cost of the lock and dam given in my above-mentioned report have been carefully revised, and the following is the result:

FOR A LOCK WITH CHAMBER 174 FEET LONG, 50 FEET WIDE, AND A LIFT OF 6 FEET TIMBER FOUNDATIONS, AND BRICK CONCRETE WALLS FACED WITH TIMBER.

46,511 cubic yards excavation, at 40 cents per cubic yard	$18,604 40
1,321,838 feet, board measure, timber, at $25 per M	33,045 95
10,271 cubic yards concrete, at $10 per cubic yard	102,710 00
137,690 pounds iron bolts, at 4 cents per pound	5,507 60
450 linear feet sheet-piling, at $1 per linear foot	450 00
Gates and fixtures	15,000 00
	175,317 95

FOR A TIMBER DAM, WITH 265 FEET LENGTH OF CREST AND CRIB SHORE-PROTECTIONS.

682,920 feet, board measure, pine timber, at $25 per M (including sheet-piling)	$17,073 00
10,865 oak pins, 8 inches long, at $12 per thousand	130 38
7,420 oak pins, 16 inches long, at $24 per thousand	178 08
53,468 pounds iron bolts, at 4 cents per pound	2,138 72
13,819 pounds boiler-plate (protection for crest of dam), at 5 cents per pound	690 95
3,291 pounds spikes, at 4 cents per pound	131 64
161 oak piles (driven), at $5 each	805 00
5,774 cubic yards excavation, at 50 cents per cubic yard	2,887 00
	24,034 77
The above prices include cost of coffer-dams, bailing, &c.	
Cost of lock and dam as above	199,352 72
10 per cent. for contingencies	19,935 27
	219,287 99

The above estimate may at first seem large, but when it is considered that all the materials, except the brick, have to be brought more than 300 miles, and that all the labor must also be brought from an equal distance, the prices are none too much.

The cost of the examination of the river, and the detailed surveys of the sites of lock and dam, was $1,906.19.

Collating the estimates on my reports of March 4, 1874, February 8, 1875, and on this report, the following is the estimate for the improve-

ment of the river from Breckenridge to the crossing of the northern boundary:

For improving the river from Breckenridge to Moorhead for raft and flat-boat navigation	$22,663 98
For improving the river from Moorhead to the head of Goose Rapids	4,428 00
For lock and dam below Goose Rapids	219,287 99
For improving the river from Goose Rapids to Frog Point	32,880 20
For improving the river from Frog Point to boundary line	85,338 00
Total	364,598 17
Appropriated by act approved August 14, 1876	10,000 00
Remaining to be appropriated	354,598 17

By January 1, 1878, the work of removing snags and overhanging trees from Moorhead to Frog Point will have been completed.

Should it be determined to build the lock and dam near Goose Rapids, at least $175,000 should be appropriated in a single sum, so that the building of the entire lock could be contracted for.

The benefits of the above improvements have been fully set forth in my former reports. Since 1874 there has been a tide of immigration setting toward the Red River Valley, and as a result, more than 700,000 bushels of wheat have been, or will be, shipped from Fargo, Moorhead, and that vicinity, from the wheat crop of 1877. The improvement of the river will allow the marketing of the crops at a rate that will leave the farmer some profit for his labor.

The work of examination was intrusted to Mr. C. J. A. Morris, assistant engineer, who deserves commendation for his energy and economy.

No tracings are forwarded with this report, as those forwarded with my report of March 4, 1874, showed the location of the proposed lock and dam, and there is nothing of interest to be seen on the maps of the bars below Frog Point. The maps are all finished, and tracings will be furnished should it be desired.

Hoping that this report may meet with your approval,

I am, very respectfully, your obedient,

F. U. FARQUHAR,
Major of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

P 17.

IMPROVEMENT OF SAINT CROIX RIVER, WISCONSIN.

No work was done during the fiscal year, no funds being available.

With amount appropriated by act approved June 18, 1878, it is proposed to build the brush and stone dams and to remove submerged boom-piers, estimated for in report of examination made in 1874 (see page 372, Part I, Annual Report of the Chief of Engineers, 1875), as far as the funds will permit of.

The estimate for the improvement was $21,758.

Money statement.

Amount appropriated by act approved June 18, 1878	$10,000 00
July 1, 1878, amount available	10,000 00
Amount (estimated) required for completion of existing project	11,758 00
Amount that can be profitably expended in fiscal year ending June 30, 1880	11,758 00

APPENDIX Q.

ANNUAL REPORT OF CAPTAIN AMOS STICKNEY, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1878.

UNITED STATES ENGINEER OFFICE,
Keokuk, Iowa, July 13, 1878.

GENERAL: I have the honor to transmit herewith my annual report of operations for improvement of the Des Moines Rapids, Mississippi River, for the fiscal year ending June 30, 1878.

Very respectfully, your obedient servant,

AMOS STICKNEY,
Captain of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

IMPROVEMENT OF DES MOINES RAPIDS, MISSISSIPPI RIVER.

This work was in charge of Col. J. N. Macomb, Corps of Engineers, U. S. A., from the beginning of the year till November 16, 1877, during which time I had special supervision of it as his assistant.

On November 16, 1877, I relieved him of the charge, in obedience to Special Orders No. 224, paragraph 3, dated Headquarters of the Army, Adjutant-General's Office, Washington, D. C., October 31, 1877, and have had charge since that date.

The work during the fiscal year has been confined principally to placing the canal in condition for navigation, which occupied from July 1 till August 22, the day of opening, and since the latter date to operating and maintaining the canal and making repairs rendered necessary by the lifting of the lock miter-sills. This limiting of the work was rendered necessary by the fact that no special provision was made by Congress for paying the expenses of operating the canal during the fiscal year until April 30, 1878, when an appropriation of $7,500 was made, sufficient to pay the expense of the remaining two months of the year.

During the summer of 1877 the Mississippi River fell to a very low stage. On the 1st of August the Keokuk Northern Line Packet Company found it necessary to withdraw their large steamers from the rapids, and a short time after, the water continuing to fall, all navigation on the rapids ceased.

The demands for the canal were loud and urgent, and we put forth every effort to get it ready for navigation at the earliest possible moment.

A great part of the worst obstructions in the channel between the head of the canal and Montrose, 4 miles above, had been removed, and although much work yet remains to be done there, a practicable channel was open for boats not too heavily ladened.

On the 9th of August the canal had been put into shape to permit the cutting of the guard-bank at the head, thus allowing the water to come

against the guard-lock gates, and on the evening of the 10th the filling-culverts at the head of the canal were opened to fill the upper level between the guard-lock and middle lock, a stretch of 5 miles. This level was filled to a depth of 4 feet in 20 hours, and the river embankment proved tight. On the 15th the lower level, about 2½ miles in length, was ready for the water, and the middle lock-sluices were opened, filling the level to a depth of 4 feet. The embankments, lock-gates, and miter sills appeared to stand well. The work of completing the lower lock machinery and dredging out the guard-banks required a few days more. In the mean time the demands for the use of the canal were becoming more and more pressing on account of the extremely low stage of the river. The citizens of Keokuk and the Packet Company had determined to celebrate the event of the opening of the canal to navigation, and finally the 22d of August was set for the day.

Owing to an accident to the distributing valve and the bursting of a pipe in the lower lock machinery, it was not until 15 minutes before the lockage of the first steamer that the upper gates of the lock were swung for the first time by the hydraulic machinery. Fortunately the machinery worked well from the very start, and has continued to do so since. On the morning of the 22d of August the United States snag-boat Montana, having on board Col. J. N. Macomb, Corps of Engineers, U. S. A., and a number of his assistants, entered the head of the canal and came down to the lower lock, where she landed. At 5 p. m. the Keokuk Northern Line steamer Northwestern entered the lower lock from below and passed up into the canal, amid much rejoicing. The two steamers were soon thronged with people and started up the canal, the *Montana* in the lead, with colors flying, bands playing, and the multitude cheering. The adjacent bluffs were lined with spectators to witness the opening to the public of this great work, which had been 10 years in course of construction.

The steamers went to the head of the canal, then turned around in it in its narrowest part and returned to the lower lock, where they arrived at about 9 p. m.

The steamer War Eagle, with a large delegation of people from Saint Louis and other river towns, did not arrive in time to participate in the opening, having got aground on a sand-bar. She reached Keokuk about 9 p. m., and came up outside to the river embankment, where she tied up abreast of the steamer Northwestern. The rest of the night was passed by the assembly in speech-making, music, and dancing. The next day the canal was thrown open for use and the public immediately availed itself of the privilege.

For the first week or two the operating of the locks was much impeded by the mud deposit, and the large quantities of moss, lily pads, and drift-wood, the accumulation of several years' growth in the canal, which was stirred up by the passage of the boats and floated into the locks. The canal remained in operation till September 13, when an examination of the lower miter-sill at the middle lock discovered the fact that the cushion-timber had been forced upward bringing the coping-course of stone-work with it, leaving an opening under the coping-course of 3 inches in the center, diminishing toward each side. The water was at once drawn from the lower level of the canal, a small coffer-dam was built and the lock pumped out. The work of repairing was pushed night and day; the entire coping-course was taken up, reset, and all the old iron dowels replaced with the addition of wedges in both ends; 10 additional bolts 1¾ inches in diameter and 5 inches in length were placed in

the cushion-timbers, and 30 additional dowels of same size placed in the face-course of the masonry.

The upper miter-sills at middle and lower locks were also examined, and, showing signs of lifting, were strengthened with new bolts and straps, and all joints regrouted. The repairs were completed on the 24th and the canal was again opened on the 25th.

The primary cause of the displacement of the miter-sills was found to be in the imperfect leading of the long bolts which pass through the cushion-timbers. The bolts were five feet long and ragged to catch the lead, but the lead chilled in pouring and did not run half way down. The bolts in the masonry were about 3½ feet long, and intended to secure the top course, 20 inches thick, to the bottom course, 28 inches thick, a provision against sliding; these bolts were simply cemented and would probably have answered their purpose if the cushion side had not raised and permitted the full head of water to lift under the top course. In rebuilding the masonry all of these bolts were wedged at top and bottom, and 24 additional bolts were placed wedged at both ends; the new bolts being 5 feet long, 1¾ inches diameter. In the cushion-timber a new bolt of same size was placed between each two of the old ones and the old ones were wedged at the bottom; all bolts being thoroughly grouted.

The upper sill at lower lock was treated in the same way, and also the upper sill at middle lock, except that instead of placing the additional bolts in the cushion-timbers I placed a strap of 2½-inch by ¾-inch iron and carried it well down the lift-wall.

The lower miter-sill at lower lock showed no signs of lifting until we had operated the canal a day or two after finishing the middle lock. As it lifted a very little, I thought I would be able to weight it down with pig-iron, and thus prevent interruption to navigation till the close of the season, but my efforts were not successful; it kept coming up slowly, and to prevent accidents, I found it necessary to make repairs at once.

On the 1st October notice was given that the canal would be closed until the 15th.

We did not succeed in cleaning the canal of rafts, &c., until the 3d October, which caused us a day or two delay, when the work of building coffer-dams was at once commenced.

In order to accommodate the current business of the boats, a coffer-dam was to have been placed at the head of the lower lock to retain the water in the lower level, so that freight could be transferred across the canal-bank at the foot of the rapids. This dam was commenced, and at least one-half of it completed, when it was discovered that the lower miter-sill at the middle lock was not yet secure. This, of course, made it necessary to draw off the water from the lower level, and cease operating the canal in the lower level entirely until the repairs to the miter-sills were completed.

At the middle lock an earthen embankment was placed surrounding the lower miter-sill, and when the water was pumped out the condition of the sill was found to be as follows: The cushion-timbers were raised from 1 to 2 inches, being highest at center of lock. A few of the stone of the coping course were raised, the highest being about 1½ inches above its proper position. Many of the vertical joints of cement and a considerable portion of the bed-joints had been washed out, and one or two stones had settled down a little. The cement used in repairing this sill was of the best brand of the Louisville Mills, and, as it seemed to set well while using it, I was very much surprised to find that it had washed out. Four or five of the bolts in the cushion-timbers were loose enough to be extracted, though with considerable difficulty; others could

be drawn up an inch or two, and the rest could not be moved by screwing on the nuts with a wrench having a lever of 4 feet and turned by 3 men.

In making repairs, I found it impracticable to rebuild the coping course without breaking the stone all to pieces and consuming much time.

The stone all being sound and not much out of place, I concluded not to move them, but to bolt them down more securely and grout the joints as well as possible, so as to make the sill hold until the close of the season of navigation would give an opportunity for more complete repairs. In pursuance of this, I placed in each cushion-timber 17 additional bolts, and in each stone of the whole coping 2 additional bolts. These bolts, are 7 feet long, 1¼ inches diameter, driven on a ½-inch wedge, with screw-thread on top with nut and washer, the washer on stone being of boiler plate 5 inches square.

The bolts were put in the holes hot and sulphur poured around them. Since the resumption of navigation, many examinations, made with the levels and by a diver, have not discovered any lifting of this sill, though there was some leakage under the coping course at points not reached by the grouting.

At the lower lock a coffer-dam was placed between the wing-walls below the lower gates and the lock pumped out. The cushion-timbers of the miter-sill were found to be up from 2 to 3 inches, and the whole coping raised bodily, as in the first instance at the middle lock. In the center it had raised from its bed about 1¼ inches, diminishing to nothing at the chamber walls. The vertical joints were unbroken. As at the middle lock, the leading of the bolts was an absolute failure, the lead having chilled and blocked up the holes without reaching the bottom.

Repairs consisted in grouting the bed-joint, and placing 101 additional bolts along the faces of the wall. Pine wedges were driven into the bed-joint, those on the lower side being confined by 3-inch plank fitted against the stone and bolted down. The grouting of the bed-joint was accomplished by drilling holes through the coping. The bolting was similar to that at middle lock, except that the bolts in the cushion-timbers and the stone immediately back of them were 1¾ inches diameter, and only 10 additional ones were placed in each cushion-timber.

The hold of every bolt was tested before panning sulphur, by 3 men turning the nut with a wrench having a lever of 5 feet. Advantage was taken of this opportunity to make the upper sill still more secure by adding 22 bolts, and placing 3 additional straps on each cushion-timber. An examination of the culverts of this lock showed that the concrete bottom had been considerably washed out, and would need attention. All repairs were completed and the canal opened for navigation on the morning of October 18.

During these repairs the whole force was at work night and day without cessation.

The canal remained in continuous and successful operation from October 18 to December 10, when it was closed for the winter.

The navigation of the river above this point ceased after November 30; the canal was virtually closed for through business; but, in order to accommodate boats wishing to harbor in the canal and on account of the movements of the dredge, the locks were kept open until the 10th December. Two large side-wheel steamers and several smaller craft took advantage of the privilege and harbored in the canal during the winter for safety from ice.

Substantial coffer-dams were constructed during the month of December across the head and foot of the canal, for the purpose of making a

thorough examination of the entire work, making such repairs or alterations as might be found to be necessary, and completing unfinished work.

A low coffer-dam was also placed at the middle lock.

An examination at the guard-lock showed that the upper and lower miter-sills and cushion-timbers had not moved, but they were given additional security by adding new bolts, as was done at the miter-sills of the other locks.

The bolts in the cushion-timber and face-stone were of 1¾-inch diameter, in the other stone 1½-inch diameter, at least 2 bolts to each stone. The bolts are 7 feet long, driven on wedges, and firmly secured by pointing melted sulphur around them, the nuts at top being screwed down firmly on wrought-iron washers.

Water compartments were built in the gates in order to give additional weight when the pressure was on them, and thus help to counteract the lifting tendency.

The middle lock was pumped out and a general examination made. The concrete bottom of the culverts was found to be washed out somewhat in places, but not enough to require repairs.

Water compartments were built in the lower gates as at the guard-lock. The lower miter-sill at this lock is the one that was most disturbed by lifting last fall. An examination showed that it had not moved since the repairs of last October.

The bed-joint under the coping course was found to be open in places where the grout had not found its way. It was regrouted as thoroughly as possible, and a calking of oakum driven under the cushion-timber.

An examination at the lower lock showed that the concrete bottom of the culverts was very badly washed out in places.

The concrete seems to have been miserably made and placed. In some places which had not yet washed out a stroke of the pick would produce a sound indicating a hollow, and upon removing an upper crust a thin stratum of mud was disclosed, showing that the surface had not been properly cleaned before placing the concrete.

This was the first lock-work done on this canal, and it was under the contract of Ephraim Owen, since deceased. From what I have heard of the man, the closest watching would not always secure good work. The repairing of the culverts with good concrete, well rammed, was thoroughly done.

The miter-sills showed no disturbance since the October repairs; but little grouting was required, and calking under the cushion-timbers, and a trench 4 feet wide was excavated in the old concrete, immediately in front of the lower miter-sill, which was refilled with good concrete carefully placed.

Water compartments were built in the lower gates as at the other locks. About the 1st of March, 1878, the work of removing the dams at the entrances of the canal was commenced and all necessary preparations were made for resuming navigation.

The canal was open for day navigation March 15, and has been in continuous and highly successful operation since.

On the 4th April a night force was put on. The lighting of the locks at night is accomplished by means of 4 small locomotive head-lights. They are placed about 12 feet above the lock walls, just back of the center of the gate recesses, and inclined slightly forward to throw the light downward. They are fastened on stands, which turn easily on a vertical axis, so that the light can be thrown in any direction to facilitate the entrance or exit of boats.

Two or three more lights of the street-lamp pattern will be added to light up the lock walls.

Since the repairing of the miter-sills last October, the canal has been in actual operation about 4½ months, during which time everything has worked in the most satisfactory manner.

The largest steamers are passed through the locks in about ten minutes, and on particular occasions have been passed through in shorter time. They pass the whole length of the canal, 7.6 miles, including 3 lockages, in a little less than two hours.

Small steamers, which are more easily handled, have made the passage in a little over one hour. The question of the advisability of allowing log and lumber rafts to use the canal was one of some doubt previous to the opening, but the first trial proved that they could be readily passed without interfering with steamboats. Of course their passage through the locks consumes some time, as they have to be divided into sections, which are pushed into the locks by their tow-boats, and pulled out by hand. No steamer is obliged to wait for more than one section to pass. Rafts do not care to use the canal except when the water is very low on the rapids. Passenger steamers, on the contrary, use the canal almost all the time rather than take even small risk on the rapids, and to escape the swift current. The matter of tolls on this work was settled during the earlier part of the construction of the canal, by a proviso in one of the appropriation bills which required "That any canal that may be constructed around said Des Moines or Lower Rapids of the Mississippi River shall be and forever remain free to the navigation and commerce of said river, and no tolls shall ever be collected."

This provision of Congress makes it necessary to have annual appropriations of money to pay the expenses of operating and maintaining the canal.

The estimated annual cost is $40,000, which provides for ordinary repairs.

The cost of operating and maintenance for the fiscal year ending 30th June, 1878, was $47,565. Only $7,500 was specially provided for the operating expenses, so that the remainder, $40,065, was taken from funds provided for construction, and should be replaced.

PRESENT CONDITION OF THE WORK.

The present condition of this work is as follows, viz: The canal proper is in thoroughly good condition for navigation. The river embankment is below grade in some places, and the riprap wall on canal side is only built up to 8 feet above canal bottom. It is essential that it should be built at least 2 feet higher as soon as practicable, to prevent wash; above that point the wall may be finished at leisure. A great deal of wall remains to be built on the river side, but as the embankment is well protected except in one or two places, by rough riprap, the building of the wall is not at once necessary.

The machinery at the lower and middle locks is completed with the exception of that necessary to operate the sluice-gates. The machinery at the guard-lock is in position, with the exception of the pumping-engine, pump, and distributing-valve, and some other minor parts. The lock-grounds are not yet completely graded nor inclosed. The channel between the head of the canal and Montrose, though practicable, requires the removal of a large quantity of rock, some of which has been chiseled and is ready to be dredged up.

It is contemplated during the present season to build the embank-

ment-wall about 2 feet higher, to finish up the lock-grounds, inclosing at least the lower lock-grounds, to finish the guard-lock machinery and engine-house, to dredge up as much as possible of the chiseled rock in channel above head of canal. This work to be done in addition to the operating and maintaining the canal.

The work done upon the improvement during the past year, in detail, is as follows, viz:

LAYING RIPRAP WALL.

Work was pushed as rapidly as the stone could be obtained and laid, and during the month of July the wall was finished to about 8 feet above grade, along the inside of the river embankment, from the guard to the lower locks, when, as the locks were not quite ready for the water and there being some stone left from a former contract on the shore side of the canal, the force was transferred to that side and as much of the exposed shore banks of the excavation-pits protected by riprap wall as could be done up to the time of filling the prism.

During the winter months while the water was out of the canal repairs to the riprap were made in some places where the wall had been found too low, and at others where it had been crushed by boats or rafts striking it. These repairs were made as well as possible with the material on hand, as new material could not be delivered until reopening of navigation.

THE FINISHING OF THE PRISM

was carried on at the same time as vigorously as possible, such as the removal of temporary cross-banks at head and foot of the canal, and some at intermediate points, which had been placed there for protection during construction of the work; also the removal of bowlders, a large growth of willows and weeds, old stumps, drift logs, a portion of the sand-bars, and general débris, the accumulation of ten years. This work should have been commenced sooner, as it was of greater magnitude than anticipated, and considerable annoyance was experienced in operating the gates of the locks with their peculiar machinery, on account of the weeds, sand, &c., being carried into them by the water and boats passing through. The filling of the opening in the bank which had been left for the purpose of allowing the water to pass out of the canal during construction, as well as the removal of the heavy cross-bank just above the lower lock, was accomplished between the 6th and 15th of August, 1877, after which the water was let in and the level rapidly filled.

While the canal was in operation during the months of August, September, October, and November, 1877, the steam-dredge was constantly in service and did excellent work in removing remains of coffer-dams in channel, both at the Montrose and Nashville dam No. 2, as well as at the lower lock coffer, which materially helped the steamers to use the approaches to the canal upon the opening. The accumulation of mud and sand below the lower lock was also partially removed, giving a narrow but deep channel to the chamber of the lock; and again during the month of October, when the canal was closed for repairs, the dredge was of invaluable service in quickly placing and removing the temporary coffers placed at the locks for keeping out the water while work was going on. Since then, except when laid up on account of ice, bad weather, or the lack of funds, the dredge has been actively and indispensably employed in deepening and widening the channel wherever it had been obstructed by bars formed from the lateral streams emptying into the canal.

The newly-constructed dump-scows have been in use for the past two weeks. The steamer Cricket is employed towing them.

During the month of January, 1878, a trench was blasted across the canal at station 338, 4 feet below grade, for the purpose of protecting the water-pipe leading from the Mississippi Brewery to the river from frost. The yearly freezing of this pipe has been a source of expense to the government and anxiety to the proprietor of the property. It is considered safe from frost now.

GUARD-LOCK.

At the beginning of this year there was still remaining a small amount of work to be done to complete the guard-lock. The slope-wall connecting the lower inside vertical wall with the canal bank and the slope, and riprap wall connecting the upper inside vertical wall with the dike were completed.

The grading immediately about the lock walls was done to cover the water-pipes and prevent their injury by frost. The rock between the lower wing-walls, where the excavation changes from lock bottom to canal bottom, had been left in a rough and irregular condition; enough of it was taken out to ease it up so that the water might have an unobstructed flow from the lock while being emptied. In connection with this a bed was excavated in the rock below the canal grade on which to rest the water-pipes which transmit the water for operating the hydraulic cylinders on the side of the lock opposite the engine-house.

The force employed at constructing the lock-gates completed their work by August 1. All that was necessary to do to them was to complete the lower gates of the guard-lock. The plank was to be put on the upper sides, the wickets to be put in, and the rods to suspend them from the columns, and all to be thoroughly painted.

SNUBBING-POSTS.

There were placed 17 cast-iron snubbing-posts at each the lower and guard-locks, and 16 at the middle lock. They were located at the most convenient points where they are used in holding vessels while in or entering the locks. They are placed on the back line of the coping on the walls, and stand 2 feet above it. They have a flange projection which rests on the wall, and the shaft enters the masonry about 3 feet. one-half let into the coping and the other half into a stone 3 feet long by 1 foot 6 inches wide jointed on back of it, and that fastened to the coping with clamps made from 2 feet by ½ foot flat iron, and secured with lead. There are also a number of oak snubbing-posts placed some distance above and below the locks on each side of the canal. The old timber delivered to build the lock-gates and afterward condemned was utilized for this purpose.

ENGINE HOUSES.

In connection with the work that was being done at the guard-lock there was a force employed at dressing stone, excavating for the foundation, and building the walls of the engine-house and cistern; the plan being essentially the same as of those built at the lower and middle locks. They are put up in the most substantial manner. The building was inclosed, the smoke-stack completed, and the slate roof put on by November 1.

REMOVING OBSTRUCTIONS TO THE CHANNEL APPROACH TO THE ENTRANCE OF THE CANAL.

The opening of the canal being of first importance, such parts of the work necessary to accomplish this was done that navigation might have the benefit of the canal during the low-water season. The remains of the upper end of the old Nashville coffer-dam had to be removed to safely admit the large class of boats, and the guard-bank at the head of the canal was to be taken out. On the 28th of July the dredge-boat just purchased for use on this improvement was put at work removing the coffer-dam, and in the mean time a force of men with teams was put at work removing the guard-bank down to the water line, using the material to fill behind the lock-walls. The bottom was taken out with the dredge-boat. Thus was all completed by August 10. The dredge-boat, the first boat ever regularly locked through one of the locks, passed through the middle lock August 21.

MACHINERY.

The work of preparing the machinery for operating the lock-gates was carried on as rapidly as possible.

At the guard-lock this work was as follows: The iron guiding circles for the chains which operate the lock-gates were placed in position on stone foundations, resting on bed-rock at bottom of the lock, and firmly secured by bolts. The operating chains were secured by a device which allows of their removal at any time.

The hydraulic cylinders were set in position and secured, the pistons placed in the hydraulic cylinders, the 24-inch culvert pulleys fastened on the coping, and pipe connections made between the cylinders and engine-house. The cistern supply-pipe was laid, the pulleys on bottom of gates adjusted, and all work which would be covered by water after the canal was filled was completed. The filling culverts were provided with a temporary arrangement for raising and lowering them, and they were opened for the first time on the 10th of August.

At the middle lock the machinery for operating the lock-gates, having been tested repeatedly, was in condition to work easily and with certainty. The sluice-gates were put in place, and on August 10 were closed as were the lock-gates and culverts, thus retaining the water which was being admitted to the upper level through the guard-lock filling-culverts.

At the lower lock the final adjustment of the machinery was made and trials had of the new distributing-valve and culvert machinery. Owing to the delays, which were caused by slight accidents, it was not possible to give the usual preliminary tests to the machinery operating the lower gates, which are the heaviest on the canal. The entire night of August 21 was spent in trying to force the gates through the thick mud which lay at the bottom of the lock, and it was not until the day of the opening, August 22, at 4 p. m., that the gates were successfully operated. Subsequent to the opening of the canal the lower and middle locks were operated with only occasional slight delays until September 13, during this period the water in the river being at such a low stage as to admit of the guard-lock gates being left open for the passage of boats directly into the upper level without lockage.

The delays which I have mentioned as occurring at the middle and lower locks were unavoidable, being caused by drift-wood and water-plants, which, torn up by the wheels of passing steamboats, were pushed

down to the locks, sometimes forming an almost solid mass, 9 or 10 feet in thickness, directly in front of the lock-gates.

The process of breaking up these jams was a slow one, but eventually the material was all floated out of the canal. The mud, which had accumulated in the lower lock since its completion, now began to wash down toward the lower gates, and packed solidly around them. This mud was of the consistency of brick clay from the pressure it received while moving the gates through it, and it proved a serious obstacle for a while, causing breakages of wire rope, pulleys, &c. The services of a diver were obtained to repair such breakages as were under water, and consequently otherwise beyond reach. In this connection I would mention that, as it was found advisable to have a diver always within reach for sudden emergencies, one of our own men was instructed in the art. A complete outfit of diving apparatus, consisting of air-pump, armor, and appurtenances, was purchased, and all such work has since been done quickly and at a very slight expense.

The machinery at the locks worked very well, and no delays were experienced in passing boats. The lower gates at lower lock were moved without difficulty after the mud had been removed from around them.

The machinery for operating the filling culverts at the head of the canal was set up and connected during the winter and satisfactory tests of its workings made. The filling culverts are 6 in number, the aperture of each being 6 feet by 3 feet, or 18 square feet area. Each culvert is covered by a sliding gate, similar in design to the recess culvert-gates at the locks.

At the top of each gate is attached a wrought-iron rod $2\frac{1}{2}$ inches diameter, on the upper end of which is a strong cast-iron rack working into a loose pinion; a $4\frac{1}{2}$-inch wrought-iron shaft extends along the top of the wall, supported at intervals on pedestals, which are bolted down to the wall. On this shaft the loose pinions above referred to are carried, and they are thrown into gear by a clutch worked by a lever, so that any particular gate or all the gates can be raised or lowered at will. The main shaft by which motion is communicated to the pinions is operated by a double-geared crab or windlass, which two men can handle easily, raising from 2 to 4 gates at once. By doubling the power on the cranks of windlass *all* the gates can be raised during any but an extreme high stage of water in the river, and one or more gates can be operated against the greatest possible pressure which can be brought to bear on them.

The guard-lock machinery not being completed, spars and capstans were constructed and put in position for operating the lock-gates by hand, and have worked well.

REPAIRS OF MITER-SILLS.

An examination of the lower miter-sill middle lock on September 13 proved that the entire coping course, which is formed of large stones, 20 inches in thickness, had been displaced vertically, being 3 inches from its bed in the center of the lock, sloping to either side, the vertical joints of cement being unbroken.

The lower level of the canal was first drawn off and a small coffer-dam constructed across the lower end of the lock; it was found necessary, however, to draw off the upper level, which was accordingly done, and the lock pumped out. A force of laborers was employed, a derrick placed in position, and the coping course of miter-sills removed and afterwards carefully reset with Louisville cement, the joints being carefully grouted. The old dowels and bolts in the cushion timbers and stone having

been removed were replaced, and additional new bolts also fastened into the bed-rock with wedges. At this time also the upper miter-sills, at middle and lower locks, were secured by means of additional bolts and dowels, and the cushion-timbers fastened down with 2½ inches by ¾ inch wrought-iron straps extending down 9 feet below the top of miter-sill wall and bolted to the face of the wall with heavy bolts driven with wedges. The work of resetting stone, regrouting joints, and placing bolts was prosecuted day and night, without intermission, until it was completed and the canal opened to navigation September 25.

During the latter part of the month of September careful observations with a level disclosed the fact that the lower miter-sill, lower lock, had been disturbed by the pressure of the water. With the hope that the displacement might be checked, at least until a higher stage of water in the river would enable steamers to pass over the rapids, the miter-sill was loaded with some 20 tons of iron, consisting of car-wheels and pig-iron bound in fagots weighing 800 pounds each. These were lowered from a flat-boat, a diver below placing them in position along the upper edge of miter-sill, and extending over the cushion-timbers. It was, however, found impossible to prevent the cushion-timber and miter-sills from slowly lifting, and it became necessary to again close the canal, which was done on the 3d of October. After the construction of a coffer-dam, and the lock being pumped out, all the machinery under the water-line was thoroughly examined, and necessary repairs made, and additional holding-down straps were fastened to the iron plates which support the machinery in the towers. As soon as the lower miter-sill could be got at, an examination disclosed that the entire coping had been raised about 1½ inches in the center or apex, gradually growing less toward the chamber walls. All of the vertical joints were unbroken and in good condition; and in making the repairs it was thought best not to separate them and remove the coping and relay it again as was previously done at the middle lock. On the upper and lower side of the sill the bed-joint was calked with long tapering wedges made of perfectly dry pine and driven as hard as the wood would stand with sledges; all of the *débris* forced into this joint by the pressure of water being previously removed as thoroughly as possible before the wedges were driven, and as much grout as possible was forced into the opening between the courses of stone.

The coping was then bolted down with 101 1½-inch and 1¾-inch bolts 7 feet long, with a fox-wedge, the bolts entering the bed-rock more than 2 feet. They were driven very hard while hot, and tested to see if each bolt had a good firm hold, and then melted sulphur poured around them until the holes were entirely filled.

The coping on the upper miter-sill was secured in the same manner, but with fewer bolts. During the time the lock was pumped out an excellent opportunity was afforded to remove a portion of the mud that had accumulated in the bottom of the lock and was the only cause of the gates not working with perfect freedom.

A force of men was put at work removing it, and succeeded, while the lock was pumped, in working it out to some distance above the apex of the gate-recesses. This mud was from 1 to 3 feet deep, and the gates had to be forced through it. It was filled with brush and water-soaked sticks, which were constantly getting foul of the chains and pulleys on the bottom of the gates.

In consequence of the great demand for the use of the canal, and the loud and villifying complaints made by the steamboat men on account of the closing of the canal, as large a force of men as could be operated to any advantage was kept at work, both day and night, drilling holes and

making and putting in bolts, so that the entire repairs were made, the coffer-dam and all rubbish removed, and the lock ready for use by October 15. About 9 working-days were consumed in making all the repairs.

At this time, also, the middle lock was examined, and some of the stones in coping of lower miter-sill found again slightly displaced and the cushion-timbers slightly raised. The lock was pumped out, and it was found that the bed of cement had been washed out from under some of the stones, thus allowing them to drop down on one side and tilt up on the opposite. As nothing short of breaking up these stones could remove them, it was deemed best to let them remain as they were, being but slightly displaced, and secure them by additional bolts, which was accordingly done. The new bolts were 7 feet long, 1¾ inches diameter, the holes to receive them being drilled through 4 feet of masonry and 3 feet of bed-rock. These bolts were placed in the cushion-timbers and the other parts of miter-sill where needed. The bolts were wedged into the bed-rock and hot sulphur poured around them, thus cementing them firmly in place. After this work was completed there were 106 bolts of 1½ inches and 1¾ inches diameter, and from 5 feet to 7 feet long, and 34 dowels, 1½ inches diameter and 4 feet long, securing the miter-sill to bed-rock.

The work of drilling and fastening bolts was carried on day and night, gangs relieving each other every 12 hours. Much rock of a flinty character was encountered, which made the drilling tedious and consumed time. By the 18th of October, the repairs being completed, the canal was opened to navigation.

GENERAL REPAIRS DURING THE WINTER.

On the 10th of December the canal was closed for the season, coffer-dams built at the three locks, and they were pumped out. The miter-sills were examined, the machinery and engines overhauled, and necessary small repairs made. At the lower lock a force of men was put at work removing the rubbish out of the culverts, and a new bottom was put in of well-made concrete. None but sound stone were used. They were well broken and mixed with good cement-mortar, then dropped through the air-pipes into the culverts, and placed and rammed. In finishing it up the concrete was carried about 12 inches up on the side-walls and rounded out in the center, leaving a kind of trough for the water to run in. In front of the upper side of the lower miter-sill an excavation was made, about 4 feet wide, down to solid rock, and a good concrete apron put in to prevent any filtration of water through any of the joints in the sill. A considerable quantity of mud was removed, the bottom being thoroughly cleaned up as far as the first filling-culvert opening. A very careful examination of the work done on the miter-sill in October discovered no signs of any yielding.

At the middle lock the lock was cleaned out for a distance of 100 feet above lower miter-sill, the miter-sill examined and found to be secure and unchanged since their last examination in October. The cushion-timbers were calked with oakum, and any open joints in the face of lock-walls were pointed up, an apron of concrete laid in front of lower miter-sill, extending 6 feet out into the lock. The culverts were examined and found to be in good general condition.

At the guard-lock the miter-sills were more securely bolted down to the rock, to correspond with the additional bolting at the other locks. The bolts securing each miter-sill are as follows: 30 1½-inch, 7 feet long; 44 1¾-inch, 7 feet long; and 10 1½-inch, 5 feet long; a total of 84 bolts,

which were fastened in the same manner as those at the middle lock. (These sills have never moved.)

At all of the locks water compartments were built in the large gates, to give additional weight when the pressure was against them.

DREDGE AND DUMP SCOWS.

In consequence of the large amount of rock to be dredged up in the channel above the head of the canal, and the constant need of dredging the material brought down by the creeks into the canal itself, it was found more economical to purchase a dredge and have it always on hand than to hire one and perhaps be delayed by waiting for it to be brought from a distance. An excellent dredge was purchased early in the year from H. S. Brown & Co., for the sum of $11,300, and it has been of very great service. In connection with this, authority was obtained for the building of two dump-scows. These were not finished and brought into use till the latter part of the year. They are very strongly constructed, are 72 feet by 18 feet over all, and have a capacity of from 60 to 70 cubic yards.

OPERATING FORCE.

The force required for operating the canal when all machinery is completed is as follows, viz:

One superintendent.	
One clerk.	
One overseer.	
Three lock-masters.	Day watch.
Three lock-engineers.	Day watch.
Three firemen.	Day watch.
Three lock-hands.	Day watch.
Three assistant lock-masters.	Night watch.
Three assistant lock-engineers.	Night watch.
Three firemen.	Night watch.
Three lock hands.	Night watch.
One sub-overseer.	For management of dredge and mud-scows, for about 4 months in the year.
One steam-engineer.	For management of dredge and mud-scows, for about 4 months in the year.
One dipper-tender.	For management of dredge and mud-scows, for about 4 months in the year.
One fireman.	For management of dredge and mud-scows, for about 4 months in the year.
One watchman	For management of dredge and mud-scows, for about 4 months in the year.
Six deck-hands.	For management of dredge and mud-scows, for about 4 months in the year.

With the above a steam tow-boat must be hired, when needed, for moving the dredge and scows.

The following rules and regulations for the government of the canal having received the appproval of the honorable Secretary of War, were printed on card-board, and a copy is handed to the master of every boat that passes through the canal with a request that it be posted in a conspicuous place on the boat, and a record of those given out is kept for reference.

These rules and regulations are generally pretty well observed, and no serious difficulty has arisen since they were published.

RULES AND REGULATIONS FOR THE GOVERNMENT OF THE DES MOINES RAPIDS CANAL, AND THOSE USING IT.—PUBLISHED BY AUTHORITY OF THE HONORABLE SECRETARY OF WAR.

1. The movement of all boats and floating things in the canal, the locks, and the approaches to the canal, shall be under the direction of the superintendent, or his authorized assistants.

2. When two or more boats or tows are waiting to enter the canal or any of the locks, the superintendent shall have authority to designate the time and order of their entrance, and no boats or tows shall enter without his authority.

3. Ordinarily, boats and tows arriving first at the locks shall have the preference in passing, but in all cases boats and barges belonging to the United States, or employed upon the work, shall have the precedence over all others; and passenger-boats shall have the precedence over tows. Rafts shall have one lockage in their turn, except where there are two or more rafts together at a lock, in which case no part of a raft shall pass the lock until the whole of the raft or rafts preceding it shall have passed.

4. Boats wishing to pass a lock shall not approach the lock nearer than a fixed point, which will be marked by a sign-board on the canal bank, until the signal is given to enter the lock, and they shall take position in rear of any boats, tows, or rafts that may precede them, and not in any way obstruct the channel.

5. When more than one boat is waiting to enter a lock, the masters must ascertain from the lock-master when their turn will come, and abide by his decision.

6. All boats, &c., arriving at the locks, and not taking advantage of the first lawful opportunity to pass, shall lose their turn.

7. All boats when in the locks shall fasten one head-line and one spring-line to the snubbing-posts on the lock walls. Large boats shall use one head-line and *two* spring-lines, and the lines shall not be unloosed until the signal is given for the boat to leave the lock. Boats shall also be provided with fenders, to be used in guarding the lock walls, &c., from injury.

8. No boat shall strike any part of the lock or sluice walls, nor any gate or appurtenance thereto, or machinery for operating the gates, nor the walls protecting the banks of the canal.

9. All rafts or tows passing the locks in sections shall "make up" just below or above the lock, on the shore side.

10. All boats using the canal shall be free from projecting irons or rough surfaces that would be liable to damage the locks or any part of the canal.

11. No boat, barge, raft, or anything shall tie up in, or in any way obstruct, the canal or its approaches, nor delay entering or leaving the locks, except by permission of proper authority.

12. No boat shall enter the canal or locks whose actual draught exceeds the least depth of water in the channel of the canal.

13. No boat shall run alongside of any other boat so as to wedge in the canal, nor shall any boat attempt to pass another boat when within 800 feet of the locks.

14. No raft or boat shall be brought through the canal, unless accompanied by a steamboat, except small boats controlled by sails or oars; and small boats used for private purposes shall not pass the locks except by permission.

15. No one shall trespass upon the canal property or in any way injure the canal, the locks, or any of the appendages.

16. No one, unless authorized by the superintendent or the lock-master, shall open or close any gate or wicket, or in any way interfere with the employés in the discharge of their duties.

17. No person shall deposit stone or material of any kind in the canal or locks, and boats passing through shall not deposit the ashes or cinders from their furnaces in the canal or locks.

18. All boats approaching the locks shall signal for the same by 4 distinct whistles of short duration, and shall not pass the point indicated by a sign-board until the lock-signal is given. The lock-signals will be: For entering, one whistle; for passing out, three short whistles.

AMOS STICKNEY,
Capt. of Engineers, Bvt. Maj., U. S. A.,
In charge Des Moines Rapids Improvements.

UNITED STATES ENGINEER'S OFFICE,
Keokuk, Iowa, April 1, 1878.

Statement of steamboats, barges, rafts, &c., passed through the Des Moines Rapids Canal from the day of opening, August 22, 1877, to June 30, 1878.

Month.	Steamboats.	Barges and flats.	Cargo.		Rafts.				Lockages.	Remarks.
			General merchandise.	Grain.	Number.	Lumber.	Shingles.	Lath.		
	No.	*No.*	*Tons.*	*Bush.*		*Feet.*	*No.*	*No.*	*No.*	
August....	22	11	.....	.....	7	7,500,000	1,000,000	4,000,000	49	
September	83	48	.....	.....	9	9,000,000	.....	.....	102	Closed eleven days for repairs.
October....	132	144	.....	.....	8	8,000,000	.....	.....	147	Closed fourteen days for repairs.
November	70	55	.....	.....	1	500,000	.....	.....	77	
December*	3	10	.....	.....	....	.....	.....	.....	4	
March*....	50	55	6,105	96,547	....	.....	.....	.....	54	
April.....	104	100	16,913	201,509	....	.....	.....	.....	113	
May.....	82	67	18,641	273,337	1	.....	2,700,000	.....	94	
June.....	124	58	11,687	166,022	....	.....	.....	.....	184	
Total....	670	548	53,346	737,415	26	25,000,000	3,700,000	4,000,000	824	

* Closed from December 10 to March 15 on account of cessation of river navigation.

The estimated cost of this work as now being carried on, given in annual report of Col. J. N. Macomb, Corps of Engineers, U. S. A., for year ending June 30, 1877, was:

Amount appropriated up to June 30, 1877	$4,281,000 00	
Amount (estimated) required for completing	95,000 00	
To this must now be added for office expenses, engineering, &c., for an additional year rendered necessary by failure to appropriate the amount estimated	12,000 00	
Total cost of construction		$4,388,000 00
Cost of operating and maintaining canal for year ending June 30, 1878	47,565,00	
Estimated cost of operating and maintaining canal for year ending June 30, 1879	40,000 00	
Estimated cost of operating and maintaining canal for year ending June 30, 1880	40,000 00	
		127,565 00
Total amount appropriated and to be appropriated for construction of work and maintenance for three years, ending June 30, 1880		4,515,565 00
Total amount appropriated up to June 30, 1878		4,383,500 00
Amount required yet to be appropriated		132,065 00

Money statement.

July 1, 1877, amount available	$105,650 30	
Amount appropriated by act approved April 30, 1878	7,500 00	
Amount appropriated by act approved June 18, 1878	95,000 00	
		$208,150 30
July 1, 1878, amount expended during fiscal year	102,861 15	
July 1, 1878, outstanding liabilities	5,328,65	
		108,189 80
July 1, 1878, amount available		99,960 50
Amount (estimated) required for completion of existing project, viz:		
To replace operating expenses for year ending June 30, 1878.	$40,065 00	
To replace operating expenses for year ending June 30, 1879.	40,000 00	
Additional	12,000 00	
		92,065 00
Amount required for operating and maintenance of canal for the year ending June 30, 1880		40,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		132,065 00

APPENDIX R.

WATER-POWER AT MOLINE, ILLINOIS.

ARMY BUILDING,
New York, June 13, 1877.

SIR: The commission designated by paragraph 6 of Special Orders No. 72, of April 5, 1877, issued in compliance with the joint resolution of Congress approved March 3, 1877, authorizing the Secretary of War to appoint a commission to examine into the matter of contracts made by and between the United States and the Moline Water-Power Company as to the water-power at Moline, Ill., having performed the duty above specified, has the honor to submit the following report thereon:

The commission first met in Washington, as directed in the order, and after examining certain maps and documents relating to contracts between the United States and the Moline Water-Power Company, which were laid before it by the acting Chief of Ordnance, and an informal discussion of the subject, adjourned to meet at Rock Island Arsenal, Ill., on May 4, 1877. Meeting at the arsenal in pursuance of this adjournment, the commission continued in session from day to day until the evening of the 10th of May, during which time all the contracts and the correspondence upon the subject, as well as the maps and plans relating to the work, were thoroughly examined, the works themselves visited, and conferences held with the president of the Moline Water-Power Company and several of the prominent manufacturers and mill-owners interested in the water-power improvement.

The history of the development of the water-power at Rock Island may be briefly stated as follows: In February, 1837, the legislature of Illinois granted to David B. Sears and associates a charter to build a dam across the "slough" to Rock Island, which charter was extended two years later, and the dam was built in 1841–'42, and two mills put up on the Moline side. This water-power was occupied by Sears and associates for several years, but in 1851 it passed, by sheriff's deeds, to Pitts, Gilbert & Pitts, who, in 1855, organized a company under a new charter. In 1859 this company issued a quantity of bonds to parties in Syracuse, N. Y., in order to raise money for repairs and improvement of their works, which not being paid, the property passed, by sheriff's deed, in April, 1864, to H. K. Whyte, jr., who held as trustee for himself and associates.

The question of the use by the government of the water-power which might be developed, both between the island and the Moline shore and between the island and Benham's Island, as a motive-power for driving machinery in the public shops to be erected on the island seems to have been first brought up prominently in November, 1865, as appears by a letter from General Rodman to the Chief of Ordnance, dated the 7th of that month. On the 18th of the same month General Rodman, in a letter to P. R. Reed, the agent of the then water-power company, presents certain questions looking toward an arrangement by which the United States should have the use of one-half the water-power developed by the company's dam.

Previously to this time negotiations had been entered into with the

owners of the water-power by Charles Atkinson and associates for the purchase of the property, and a charter was obtained by them, under the name and style of the Moline Water Company, in February, 1865; but the company does not seem to have been organized and the property purchased until December of that year, and after it became known that there was a serious intention entertained of using this power for driving the machinery in the government shops.

It should be remembered that neither this nor the previous charters did or could give any legal right to abut a dam upon the island of Rock Island, or to use the west half of the slough as a pool, without the consent of the United States Government, in which was vested the ownership of the adjacent shore of the island. The existence of the water-power from the time of the construction of the first dam to the date of the signing of the first contract with the government in 1867 was dependent upon the pleasure of the latter. Hence the contract is to be considered as a necessary preliminary to the securing by the company of any legal right to a water-power practically useful.

The Commission appointed under the acts of Congress approved April 19, 1864, and June 27, 1866, consisting of Maj. Gen. J. M. Schofield and Messrs. James Barnes and Selden M. Church, to ascertain the true value of the land on Rock Island taken possession of by the War Department, and the compensation due each claimant, reported under date of January 24, 1867, that it found it impracticable to determine as a separate question the damage sustained by the Moline Water-Power Company in the taking possession of by the United States of their one-half of the water-power, because of the inseparable character of the joint interest of the United States and the company; but recommended for adoption by the War Department the basis of an agreement with the company which they presented for the settlement of all questions pending between that company and the United States. The only conditions in this proposed agreement which have relation to the present condition of the subject are as follows:

1. The Moline Water-Power Company to convey to the United States the fee of the entire Moline water-power, and also to grant to the United States the unrestricted use in perpetuity, without charge, of so much of the bed of the river not already belonging to the United States as may be covered by the pool and wall necessary to develop the water-power, and ten feet outside of said wall, together with the right of access thereto from the Illinois shore at all times for the purpose of constructing or of repairing said wall.

2. The government to develop and maintain the power, so far as it can be done with the money heretofore appropriated and that which may hereafter be appropriated by Congress for that purpose.

3. The Moline Water-Power Company to have the use in perpetuity, free from all charge for rent or repairs, of one-fourth of the entire water-power developed, and also the right to rent for a specified time, at the rate of fifty cents per annum per square inch of water-power, measured by openings of water-wheels, so much additional power as the Ordnance Department may deem expedient.

* * * * * * *

5. Sixty thousand dollars of the present appropriation to be applied to the extension of the present stone dam on the Moline side, and $40,000 to the extension and repairs of the wing-dam and removal of such deposits as may be required for the extension and repairs of said wing-dam. The use of the present water-power shall not be unnecessarily obstructed during the construction of the proposed work, nor shall any rent be required until the improvement contemplated by the $100,000 appropriation shall have been made.

* * * * * * *

By joint resolution of Congress, approved March 2, 1867, the Secretary of War was authorized and empowered to carry into effect the recommendations of the commission above referred to, "and to make application for that purpose of the money heretofore appropriated for securing

water-power at the head of Rock Island"; and under this authority a contract was entered into by the Secretary of War for and in behalf of the United States, and Mr. Charles Atkinson, president, for and in behalf of the Moline Water-Power Company, and signed by them on the 20th August, 1867, and the 18th June, 1867, respectively.

In carrying this contract into practical effect, several questions arose regarding the construction to be given to certain points upon which the parties in interest were not agreed; and General Rodman, under date of August 5, 1868, advised that the views of the commissioners should be obtained as to the true intent of their recommendation in relation to the points referred to.

In 1869 a change of plan of dam was proposed, in order to lessen the cost of construction, which involved the excavation of a canal for carrying off the tail-water from the company's wheels, said canal to cross the lands of the company; and a second contract was entered into with the company, by which the land needed for the purpose was ceded to the United States. This contract was signed by the Secretary of War "under the authority of the joint resolution of Congress approved March 2, 1867." These two contracts are the only ones between the United States and the Moline Water-Power Company, and are those referred to in the joint resolution approved March 3, 1877, under which the present commission was appointed. If, therefore, the company has cause to complain, it must be from the failure of the United States to carry out certain of the stipulations embraced in one or both of these contracts.

The particular causes of complaint as presented by the company will be found in the communication of its president, dated May 8, 1877. They may be briefly stated as follows:

1. That the government has not constructed the wing-dam as understood and agreed.

2. It has not excavated the channel from deep water into the pool as was proposed to be done as a substitute for the long wing-dam.

3. It has not removed the deposits existing in the pool at the time of making the contract of April 8, 1869.

4. It has received transfer, and taken and holds possession of the company's property without performing the consideration agreed upon.

5. It has violated the condition of section 6 of original contract by leaving in the pool a part of the bottom of the coffer-dam, and in the water-way at mouth of the canal a mass of stone which holds back the tail-water, and is a positive detriment to the power.

6. It has failed to maintain the water-power by its neglect to remove the annual accumulations in the pool since the execution of the contracts, and which have increased to an extent which threatens at no distant day to make the entire power practically worthless for a considerable portion of the year. The company estimates the amount of these accumulations at from 133,000 to 150,000 cubic yards.

In regard to the first of the foregoing complaints, it appears that the only obligation incurred by the United States is contained in the third stipulation of the original contract and the fifth recommendation of the Rock Island Commission, by which $40,000, or so much thereof as the War Department may consider necessary, was to be applied to the extension and repairs of the wing-dam. It appears from the statement of the commanding officer at Rock Island, that the money actually paid out was $28,874.72, to which should be added $26,458.62 for stone obtained from the excavation on Rock Island Rapids improvement and charged at the same price as was paid to the Moline Water-Power Company for

similar stone, and $806.93 for labor of enlisted men; making a total of $56,140.27, or over $16,000 more than was specified in the agreement.

As regards the second complaint, there is nothing to be found in either of the contracts in reference to the excavation of the channel alluded to. Such a channel has been proposed, and an appropriation therefor asked of Congress, in order to bring into the pool the amount of water in low stages of the river needed for the full development of the power required by the government, including that to which the company would be entitled.

The third complaint seems to be founded on the third stipulation of the contract of April 8, 1869, which provides that "the United States shall resume, as early the present season as the stage of water will permit, the development and prosecute to completion, according to agreement, the upper portion of the water-power and the removal of deposits in the pool." The only reference to the removal of deposits is found in the fifth recommendation of the Rock Island Commission (which recommendations form a part of the original contract), wherein it is provided that $40,000 shall be applied "to the extension and repairs of the wing-dam and removal of such deposits as may be required for the extension and repairs of said wing-dam." In fact, however, it appears from the statement of the commanding officer that 121,010 cubic yards of deposit were removed from the pool during the months of May (the date of the contract) to December of that year.

The fourth complaint being of a general nature, will be considered further on.

As regards the fifth complaint, it is stated by the commanding officer in his communication of the 13th June, 1877, that a great deal of attention has been given to the removal of the bottom of the old coffer-dam, and that he is satisfied that not enough remains to form an "obstruction" to the pool; that the site of this coffer-dam is in a deep part of the pool compared with the depth at the head, and that the water, in the lowest stage of the river, stands level over this part of the pool, which it would not do if there were an obstruction at that point. Respecting the second part of the complaint, the commanding officer states that the canal was excavated under his supervision, and that a mass of stone was not left in the mouth of the canal, and that none has been put there since its completion.

The sixth alleged grievance is met in part in the remarks regarding the third, where it is stated that the only reference to the removal of deposits was to be found in the fifth recommendation of the Rock Island commission, that such deposits shall be removed as may be required for the extension and repairs of the wing-dam; the cost of the removal to be paid out of the $40,000 assigned to said extension and repairs. It is undoubtedly true that the entrance to the pool is now so obstructed by the accumulation of deposits as to practically keep out the water in low stages of the river, so that on this account the mills are then without power. The average time of each year when the mills are without serviceable power was estimated by the mill-owners who appeared before us at three months, and three months with half-power.

There are fifteen wheels in use, affording about fifty horse-power each, or seven hundred and fifty in all. The above estimate of the time during which the mills are without sufficient water-power would seem to be much exaggerated, judging from the record of the daily stages of water kept by the Ordnance Department.

Although the United States have nowhere specifically agreed to remove the deposits in the pool, except as stated in the fifth recommendation of

the Rock Island Commission, and in the contracts of 1867 and 1869, which provide for the "removal of such deposits as may be required for the extension and repairs of the wing-dam," a removal which was fully accomplished long since, yet it appears from the statement of the commanding officer that there was actually removed between January, 1869, and October, 1876, the large amount of 151,265 cubic yards.

The fourth complaint charges, in a general way, that the United States has received transfer and holds possession of the company's property without performing the consideration agreed upon, while it appears that the only consideration in the contracts was that the United States should apply the existing appropriation of $100,000, and any future appropriations that might be made, to the development and maintenance of the water-power, giving to the company one-fourth the power so developed free of cost, with the privilege of taking at a nominal rent an additional amount not needed by the government. The United States has actually expended for these purposes the sum of $758,227.21.

From what has been stated it appears that the specific complaints of the Moline Water-Power Company are not sustained, with the possible exception of the fifth. It is presumable, however, that the company expected, in transferring its share of the water-power privilege in question (one-half), that the government would go on with its development to the extent required for the purposes of the arsenal, including the removal of such of the deposits from the pool, and the opening of a sufficient channel into the same, to secure the requisite supply of water in low stages; and it is natural, perhaps, that disappointment should be felt that this expectation has not been fully realized. All this will still be done if, as is presumed, the government shall use the water as a motive-power for the shops, instead of steam. The dams are all built, the gates are in place, and the machinery ready for setting up. The cost of this power will be only nominal as against at least $60 per horse-power per annum for steam; and as the commanding officer estimates that provision should be made for at least two thousand horse-power for government purposes, there would be a saving of, say, $120,000 per annum by using water instead of steam when running to the extent referred to.

Respectfully submitted.

A. A. HUMPHREYS,
Brigadier-General and Chief of Engineers, Bvt. Maj. Gen., U. S. A.
H. G. WRIGHT,
Lieutenant-Colonel of Engineers, Brevet Major-General.
HENRY L. ABBOT,
Major of Engineers, Brevet Brigadier-General.

Hon. GEORGE W. MCCRARY,
Secretary of War, Washington, D. C.

APPENDIX S.

ANNUAL REPORT OF CAPTAIN WM. R. KING, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1878.

UNITED STATES ENGINEER OFFICE,
Chattanooga, Tenn., September 3, 1878.

GENERAL: I have the honor to submit annual reports on the works under my charge for the fiscal year ending June 30, 1878.

Very respectfully, your obedient servant,

W. R. KING,
Captain of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

§ 1.

IMPROVEMENT OF TENNESSEE RIVER.

ABOVE CHATTANOOGA.

As no appropriation was made for this work for the fiscal year 1876 and 1877, it has remained suspended during the year, and such of the boats and tools as could not be used to advantage on other works have been laid up in charge of watchmen.

When the appropriation of June 18, 1878, became available, steps were taken to reorganize working parties, rebuild boats, and supply the necessary outfit of tools and supplies for a vigorous prosecution of the work at Chota Shoals and other points below Knoxville, and it is hoped that before the end of the present low-water season considerable work will be done.

The necessity of this work has been set forth in former reports, and I will therefore simply recapitulate some of the facts showing the nature and importance of the improvement.

During the greater part of the year the river from Knoxville to Chattanooga, in fact to Decatur, Ala., a distance of 363 miles, is navigable by steamers drawing from 2½ to 3 feet of water, and some 10 boats of from 30 to 260 tons capacity have been engaged in this trade during the past year. When the water becomes low, obstructions are met with at various points; but most of them as far up as Loudon, Tenn., and some above that place have been improved so as to become comparatively small obstructions. It is proposed to continue work on these obstructions as far as Knoxville, and to still further improve and finish up some of the works below Loudon.

The improvements generally consist in building stone dams and excavating rock and gravel from the channel, to give increased depth of water across the reefs and shoals. The river bed and banks are ex-

exceptionally permanent, and the river is never frozen so as to obstruct navigation. The improvement is, therefore, not only permanent but will be available throughout the year.

The record of the river-gauge kept at the bluffs near this city will be found plotted on a sheet herewith inclosed.

The estimate of cost of improving the Tennessee River above Chattanooga was originally assumed to be $175,000. This has of necessity been increased by the construction of additional dams at various points and other contingencies, as explained by Major McFarland in Report of the Chief of Engineers, 1874, page 573.

There has been appropriated for this work $180,000. Of this amount, $164,[illegible]83 have been expended.

Money statement.

July 1, 1877, amount available	$150 28	
Amount appropriated by act approved June 18, 1878	15,000 00	
		$15,150 28
July 1, 1878, amount expended during fiscal year	96 11	
July 1, 1878, outstanding liabilities	71 17	
		167 28
July 1, 1878, amount available		15,000 00
Amount (estimated) required for completion of existing project		45,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880		35,000 00

BELOW CHATTANOOGA.

Work on this part of the river has been continued during the year, and, notwithstanding vexatious delays, incident to the contract system, and to bad weather, sickness, &c., fair progress has been made.

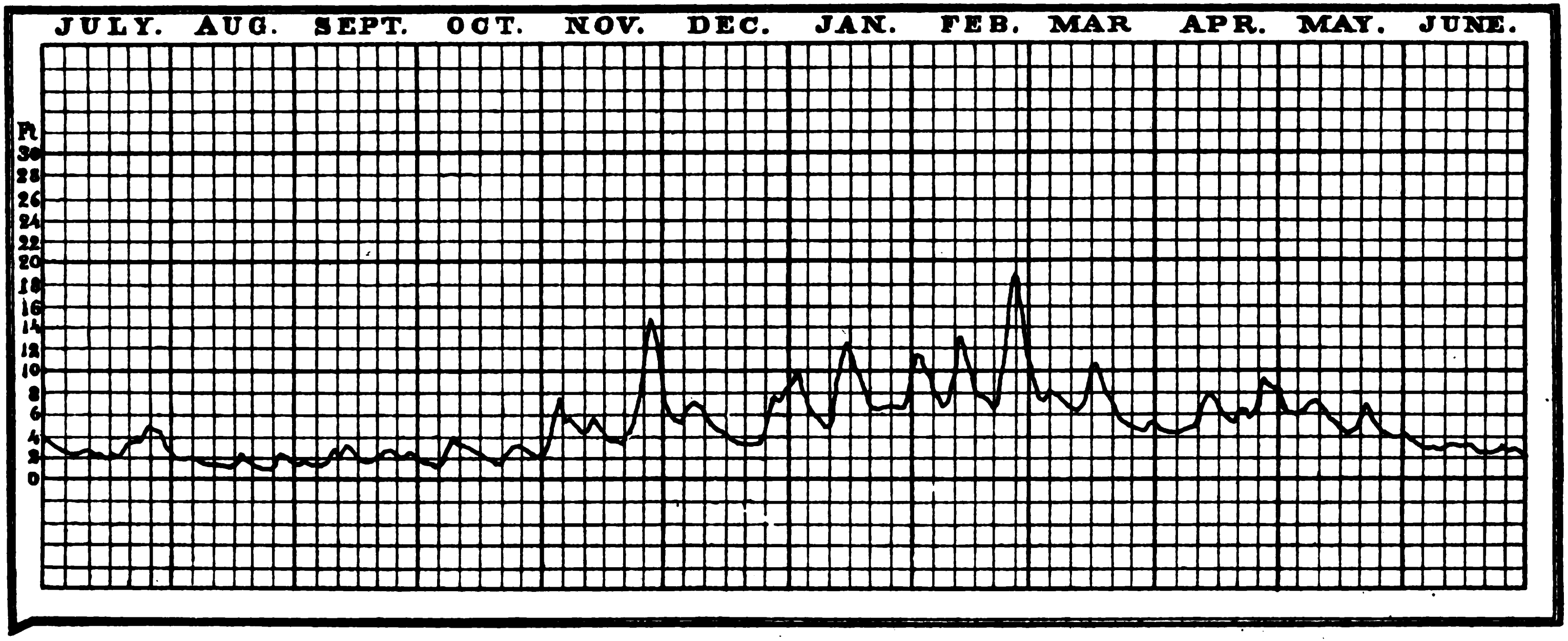
The work will be considered in five divisions, as follows, the first three of these constituting what is known as the Great Muscle Shoals obstruction.

A.—ELK RIVER SHOALS.

Further examination confirms the opinion expressed in the last report, that this obstruction can be overcome at a much less cost than originally estimated, and as soon as the new appropriation was available an outfit of boats, tools, and supplies was procured for a large force of workmen, authority having been obtained to do the work by hired labor.

The work is now making good progress. Boats and cabins for the men are being built, and a temporary dam 2,000 feet long has been built from the south shore to Brown's Island, which will enable the excavation of reefs in the channel at the head of the shoals to be carried on to good advantage, as has been done at Little Muscle Shoals under similar conditions. Mr. Samuel Whinery, Assistant-Engineer, is in local charge of this work, and is pushing it with energy.

WATER-GAUGE TENNESSEE RIVER AT THE BLUFF.
CHATTANOOGA, TENN.
1877-78.



TO ACCOMPANY ANNUAL REPORT, 1878.

W. R. King Capt. Engrs

No 1.—Muscle Shoals Canal.—April, 1878.

Lock No. 9.

No. 2.—Muscle Shoals Canal.—April, 1878.

Lock No. 3.

No. 3.—Muscle Shoals Canal.—April, 1878.

Lock No. 4.

No. 4.—Muscle Shoals Canal.—April, 1878.

Excavation for Lock No. 6.

No. 5.—Muscle Shoals Canal.—April, 1878.

Excavation for Lock No. 7.

No. 6.—Muscle Shoals Canal.—April, 1878.

Excavation for Lock No. 8.

No. 7.—Muscle Shoals Canal.—April, 1878.

Temporary Dam at Little Muscle Shoals.

No. 8.—Muscle Shoals Canal.—April, 1878.

Excavating Reef in Channel at Little Muscle Shoals.

B.—MUSCLE SHOALS CANAL, "BIG MUSCLE SHOALS."

This work has been continued under two contractors, with the following results:

Contractors.	Locks.	Date of contract.	Excavation, cubic yards.				Earth embankment, cubic yards.	Masonry, cubic yards.				
			Earth.	Hard pan and loose rock.	Rock.	Old locks.		Cut-stone.	Rock-face.	Rubble.	Concrete.	Slope-wall.
		1876.										
George Williams ...	2	Oct. 14	101	.....	516	907	1,137	1,341	.....	1,610	101	80
George Williams ...	3	Mar. 31	340	.....	6	414	9,793	2,163	.....	2,796	.....	329
George Williams ...	4	Mar. 31	1,387	.....	.....	.....	6,810	2,083	.....	1,095	.....	228
					3							
		1877.										
S. N. Kimball	6	Sept. 25	1,833	11	3	.....	.....	.....	.....	.....	.....	.....
S. N. Kimball	7	Sept. 25	4,924	1,680	2,460	981	.....	47	133	756	.....	.....
S. N. Kimball	8	Sept. 25	2,962	.....	2,414	1,085	.....	.....	.....	5	.....	.....
S. N. Kimball	9	Sept. 25	735	800	360	.....	.....	.....	.....	.....	.....	.....
S. N. Kimball	10	Sept. 25	.....	.....	.....	1,644	.....	.....	.....	.....	.....	.....
Total.....	....	.....	12,282	2,491	5,759	5,031	17,740	5,634	133	6,262	101	637

The contracts cover the removal of fourteen old locks and the excavation of foundation-pits, furnishing materials for and the building of the masonry of eight locks 300 feet long, 60 feet wide, and from 5 to 12 feet lift, the walls being of heavy cut stone and rubble masonry laid in hydraulic cement and founded upon solid rock. At the end of the year three of these locks, Nos. 2, 3, and 4, had been completed, the foundation-pits of two others had been excavated and the masonry commenced, while a quantity of stone had been quarried and cut, and the excavation commenced for two more.

Mr. Kimball's contract was to have been completed on the 30th of June, 1878; but he has applied for an extension of one year, six months of which has been granted, but it is not probable that he will complete his contract in that time.

It was decided to start two large forces of hired laborers at work on the repair and enlargement of the canal-trunk, and they are now making excellent progress.

C.—LITTLE MUSCLE SHOALS.

This work has been carried on by hired labor, and has made excellent progress.

A temporary dam, 1,400 feet long, was placed across the channel to be improved, and the work of excavation was commenced last winter before the flood season, and was renewed in the spring as soon as the stage of the water would permit, the interval of high water being employed in quarrying rock for dams.

The following is a statement of the quantities of rock quarried and of rock excavated from the channel:

	Cubic yards.
Rock quarried for dams.....	14,829
Rock excavated from channel	8,038

The average cost to the government of rock quarried was 97½ cents per cubic yard, and for rock excavated from channel $1.94 per cubic yard.

which will compare favorably with the cost of any similar work in this vicinity, whether done by contract or by hired labor. In addition to the direct work of improvement, a large amount of work was done in building and fitting up boats and derricks and in building temporary quarters for the men. Mr. J. E. Willard, assistant engineer, has been in local charge of this work and of that at Colbert Shoals during the year.

D.—COLBERT SHOALS.

Work was resumed on this obstruction in July, 1877, and continued until November, 1877, when it was suspended on account of high water.

The work done consisted in rock excavation at Canton Reef and other points, and the repair and extension of certain parts of the stone dams. The quantities were as follows:

	Cubic yards.
Rock excavation	379
Rock put in dams	5,092

The general effect of this season's work has been to increase by several inches the available depth of water, and has reduced this obstruction to one of secondary importance, as is indicated by the fact that pilots now complain of obstructions at other points, whereas until last season's work was begun this was considered the most formidable obstacle to navigation below Florence. A small amount of work remains to be done, which it is hoped can be completed during the present low water season; and when this is done the formidable obstruction of Colbert Shoals will be as nearly overcome as practicable without resorting to locks and dams.

E.—DUCK RIVER SHOALS.

This obstruction was surveyed in 1875, but no work has been done on it, as the appropriations have been too small to justify the withdrawal of funds from the more important improvements on the Lower Tennessee. The last appropriation bill, however, containing an item of $15,000 for this work, arrangements are being made to put a force at work on these obstructions as soon as the necessary tools and appliances can be spared from Little Muscle and Colbert Shoals.

The Tennessee River is in the collection-district of New Orleans. The nearest port of entry is New Orleans. The amount of revenue collected at that port is not known to me.

The original estimate of the cost of improving the Tennessee River below Chattanooga was $4,133,000. From 1868 to 1878 the sum of $1,335,000 has been appropriated. At the close of the fiscal year $817,472.50 of this amount had been expended.

As stated in my last report, it is not probable that the entire amount of the original estimate will ever be required. During the present year it is expected that the work will be in such a condition that a revised estimate can be made of the amount necessary to complete the work, and there is every reason to believe that this amount will be very much below the original estimate.

Money statement.

July 1, 1877, amount available	$431,670 96	
Amount appropriated by act approved June 18, 1878	300,000 00	
		$731,670 96
July 1, 1878, amount expended during fiscal year	213,643 46	
July 1, 1878, outstanding liabilities	20,059 58	
		233,703 04
July 1, 1878, amount available		497,967 92
Amount (estimated) required for completion of existing project		2,797,500 00
Amount that can be profitably expended in fiscal year ending June 30, 1880		700,000 00

S 2.

IMPROVEMENT OF CUMBERLAND RIVER.

This work has been continued under the immediate charge of Capt. L. C. Overman, Corps of Engineers, by the hired-labor system.

The available working season was very much shortened by the exhaustion of the appropriation, which occurred in October, 1877, when the boats and other property were laid up in charge of watchmen.

The importance of the improvement of the Cumberland River has been set forth in former reports. There are about fourteen steamers engaged in commerce on the Cumberland, with an average capacity of about 320 tons. From Point Burnside to the mouth of the river there are some 550 miles of navigable water; the object of the improvement being to deepen the low-water channel at the shoals, and thus increase the length of the season of navigation.

The Cumberland River has been divided by the appropriation acts into five sections, viz:

1. Below Nashville.
2. From Nashville to the Kentucky line.
3. From Kentucky line to Smith's Shoals.
4. Smith's Shoals.
5. From Smith's Shoals to Falls of the Cumberland.

I.—BELOW NASHVILLE.

No appropriation having been made for this section in the act of August, 1876, no work was done on it during the year, but such of the boats and tools as could be used to advantage on the river above Nashville were utilized for that purpose.

As soon as the appropriation of 1878 was available, working parties were organized and supplied with boats and tools for resuming work at Harpeth and Dover shoals, and other points between Nashville and the mouth of the river.

The original estimate of cost of improving Cumberland River below Nashville was $248,821. The sum of $145,000 has been appropriated, and $99,991.37 expended at the close of the fiscal year.

Money statement.

July 1, 1877, amount available	$336 63	
Amount appropriated by act approved June 18, 1878	45,000 00	
		$45,336 63
July 1, 1878, amount expended during fiscal year		328 00
July 1, 1878, amount available		45,008 63
Amount (estimated) required for completion of existing project		103,821 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		70,000 00

II.—ABOVE NASHVILLE.

Work was in progress upon the four sections above Nashville at the beginning of the fiscal year, and was continued until the available funds were expended, with the exception of a small balance necessary for the care of the boats and other property pertaining to the work.

The work done on the different sections was as follows:

1.—NASHVILLE TO THE KENTUCKY LINE.

At Sand Shoals:
300 cubic yards of rock were excavated from the channel and placed in two small wing-dams.
At Cub Creek Shoals:
1,100 cubic yards of stone dams built.
105 cubic yards of rock excavated from channel.
1,000 cubic yards of gravel excavated from channel.
13 logs and overhanging trees removed.
At Bartlett's Bar:
307 cubic yards of stone quarried for dams.
417 cubic yards of dam built.
At Holliman's Island Shoals:
2,100 cubic yards of gravel excavated from channel.

A steamer was employed fifteen days in scraping bars on this section.

Twenty snags, averaging 40 feet long by 2½ feet in diameter, were removed, and 58 overhanging trees, averaging 40 feet long by 2 feet in diameter, cut down by snag-boat.

Work was suspended on this section August 6, 1877.

Money statement.

July 1, 1877, amount available	$7,182 27	
Amount appropriated by act approved June 18, 1878	20,000 00	
		$27,182 27
July 1, 1878, amount expended during fiscal year		7,174 46
July 1, 1878, amount available		20,007 81
Amount (estimated) required for completion of existing project		87,155 00
Amount that can be profitably expended in fiscal year ending June 30, 1880		60,000 00

2.—KENTUCKY LINE TO SMITH'S SHOALS.

At Wild Goose Shoals:
220 cubic yards of rock quarried for dams.
258 cubic yards of rock excavated from channel.
3,000 cubic yards of gravel excavated from channel.
780 cubic yards of dam constructed.

Three hundred and fifty snags and overhanging trees, from 10 to 40 feet long and from 1 to 3 feet in diameter, were removed by the snag-boat.

Work was suspended on this section October 6, 1877.

Money statement.

July 1, 1877, amount available	$8,752 20	
Amount appropriated by act approved June 18, 1878	8,000 00	
		$16,752 20
July 1, 1878, amount expended during fiscal year		8,741 30
July 1, 1878, amount available		8,010 90
Amount (estimated) required for completion of existing project		73,609 00
Amount that can be profitably expended in fiscal year ending June 30, 1880		50,000 00

3.—SMITH'S SHOALS.

At Long Shoal:
1,620 cubic yards of stone quarried for dams.
8,550 cubic yards of stone placed in dams.
At Mill Shoal:
1,050 cubic yards of stone excavated from channel and placed in dams.
950 cubic yards of dam constructed.

Work suspended on this section September 18, 1877.

Money statement.

July 1, 1877, amount available	$17,572 89	
Amount appropriated by act approved June 18, 1878	30,000 00	
		$47,572 89
July 1, 1878, amount expended during fiscal year		17,625 52
July 1, 1878, amount available		29,947 37
Amount (estimated) required for completion of existing project		15,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		15,000 00

4.—SMITH'S SHOALS TO THE FALLS OF THE CUMBERLAND.

On this section 1,650 cubic yards of rock, consisting of dangerous bowlders, &c., were removed from channel.

Work was suspended August 19, 1877.

Money statement.

July 1, 1877, amount available	$2,000 00	
Amount appropriated by act approved June 18, 1878	2,000 00	
		$4,000 00
July 1, 1878, amount expended during fiscal year		1,978 68
July 1, 1878, amount available		2,021 32

The estimates of cost of improving Cumberland River, above Nashville, amount to $283,764. The sum of $112,000 has been appropriated, and of this amount $52,012.60 had been expended at the close of the fiscal year.

This work is in the collection-district of New Orleans. The amount of revenue collected at the nearest port of entry is unknown to me.

S 3.

IMPROVEMENT OF HIAWASSEE RIVER.

The good progress reported at the end of last fiscal year was continued until the 1st of October, 1877, when, the funds being nearly expended, the work was closed for the season and the property placed in charge of watchmen.

Mr. John S. Crary, assistant engineer, has continued in charge of the work, and the results obtained have been highly satisfactory as to cost, amount, and character of the work.

The following are the principal items of work done during the year:

403 cubic yards of rock and gravel excavated from channel.
879 cubic yards of rock quarried for dams.
2,784 cubic yards of rock placed in dams.

Also a number of logs, snags, bowlders, and a large quantity of drift-wood were removed from the channel.

This work was done principally at Mathews' Shoals, Magil's Island Shoals, and Towhead, and at Blackbird Shoals.

The south dam, 270 feet long, at Mathews' Shoals, is completed.

Work was resumed as soon as the appropriation of June 18 was available, and is now making good progress.

Although the season's work is not far enough advanced to form a definite judgment on the subject, it is not probable that the present appro-

priation, which exhausts the original estimate, will complete all that it is desirable to do on the Hiawassee up to Savannah Ford.

The reason why the original estimate will probably prove too small may be attributed to the facts that the work is being done in the most thorough and substantial manner, and that some of the rock encountered proves to be of the most refractory kind, which greatly increases the cost of excavation.

From the best information at present available, it is probable that at least $10,000 more will be required to complete the work, and that amount is accordingly recommended.

The obstructions on this river are of the same general character as those on the Upper Tennessee, and the regimen of the river is equally permanent. The improvements will, therefore, be permanent when completed, and the results show that they will secure the additional depth required to make a low water channel from 2½ to 3 feet deep at the shoalest places.

The original estimate for improving the Hiawassee from Savannah Ford to the Tennessee River is	$20,000 00
Amounts appropriated	20,000 00
Amount expended	9,959 95

Money statement.

July 1, 1877, amount available	$9,718 80	
Amount appropriated by act approved June 18, 1878	10,000 00	
		$19,718 80
July 1, 1878, amount expended during fiscal year		9,678 75
July 1, 1878, amount available		10,040 05
Amount (estimated) required for completion of existing project		10,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880		10,000 00

S 4.

IMPROVEMENT OF COOSA RIVER, GEORGIA AND ALABAMA.

At the beginning of the fiscal year work had been started at Horseleg Shoals, near Rome, and preparations were being made to commence at other obstructions between that point and Greensport.

The work was under the immediate direction of Lieut. W. L. Marshall, Corps of Engineers.

In addition to the labor of building derrick and quarter-boats, &c., the following work was done during the year:

1. Horseleg Shoals:

About 354 cubic yards of rock excavated from channel.
About 370 linear feet of riprap dams built.
About 568 linear feet of rock and gravel dams rebuilt.
About 1,100 linear feet of crib-dams built.
A large quantity of rock quarried for dams.

2. Turkeytown Island:

About 100 cubic yards of rock excavated from channel.
About 980 cubic yards of riprap dams built; 3 snags removed.

3. Copperas Bluffs:

About 341 cubic yards of rock excavated from channel.

4. Cross Shoals:

About 225 cubic yards of rock and gravel excavated from channel.
About 225 cubic yards of rock and gravel placed in dams.
About 150 linear feet of riprap dams built; 12 snags removed.

5. Greensport Reefs:
About 581 cubic yards of rock and gravel excavated from channel; 12 snags removed.

6. Mill Shoals:
About 78 cubic yards of rock excavated from channel.
About 425 linear feet of crib-dams built.
About 300 linear feet of brush and gravel dams built.
About 362 cubic yards of rock quarried for dams; 2 snags removed.

At Whistenant's Mill Shoals and. Ten Island Shoals, which are the most formidable ones between Rome and the Selma, Rome and Dalton Railroad bridge, it was found necessary to make a careful survey with a view to deciding and locating the necessary works of improvement. Lieut. W. L. Marshall's report on this survey is appended, and the plan proposed for the improvement consists of two dams to give the necessary depth of water, and three locks to furnish a means of communication between the different water-levels thus established. The plans and specifications of these locks having been completed, authority will be asked to place two of them under contract at once. When these obstructions are overcome there will be a practicable water-line of communication between Rome, Ga., and the coal-fields of Saint Clair County, Alabama.

Work closed on account of high-water in November, 1877, and was resumed again in June, 1878.

The original estimates of the cost of improving the Coosa River are	$552,347 00
Amount appropriated	105,000 00
Amount expended	16,150 67

Money statement.

July 1, 1877, amount available	$29,760 59	
Amount appropriated by act approved June 18, 1878	75,000 00	
		$104,760 59
July 1, 1878, amount expended during fiscal year	15,911 26	
July 1, 1878, outstanding liabilities	1,805 74	
		17,717 00
July 1, 1878, amount available		87,043 59
Amount (estimated) required for completion of existing project		447,347 00
Amount that can be profitably expended in fiscal year ending June 30, 1880		150,000 00

REPORT OF LIEUTENANT W. L. MARSHALL, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Rome, Ga., July 9, 1878.

SIR: I have the honor to submit the following report of the results of a resurvey of Whistenant's and Ten Islands Shoals, Coosa River, Alabama, made during the latter part of May and first part of June, 1878, by Mr. R. C. McCalla, assistant engineer, and Mr. Edward Mead. Mr. McCalla would have prepared the report had it not been that his services have been constantly required with the parties now at work upon the river. The survey was directed to the examination of definite lines selected by myself after a close reconnaissance of the obstructions, which accounts for the want of data upon the maps along the left or east bank of the stream.

The obstructions in question extend from about one-half mile below Greensport, Ala., to the foot of Wood's Island, or for about 5 miles, in which distance the total fall in the water's surface is 24.01 feet, of which 5.9 feet in 3,000 feet, or 5.56 feet in 2,500 feet, occurs at Whistenant's Shoals, and 17.77 feet on Ten Islands Shoals, in a horizontal distance of 2.6 miles, 16.26 feet of which latter fall is in less than 2 miles.

At Whistenant's Shoals the river suddenly widens, from about 600 feet to about twice that width, and falls over three distinct series of sandstone reefs, which extend entirely across the river, with the exception of a narrow flat-boat channel near the left bank, through which the water pours with great velocity and violence. At the foot of this chute is a gravel-bar, which extends downstream against that bank for a distance of

reef to below McConnel's Bar. Over McConnel's Reef, near the right bar of 2.28 feet in 140 feet. On the left side the reef is very wide, and the de gradual, the reef spreading out into a broad collection of thinner reefs an slabs of sandstone; from the foot of McConnel's Bar to the head of Wood's water flows over a succession of sandstone reefs, with no very abrupt falls varying in depth from a few inches on the reefs and rocks to from 2 to 3 fe them, in holes and pockets. It is difficult to navigate a light batean over the shoal. To the left of Wood's Island the fall is rapid to the level of the occupies about two-thirds the length of the island on that side. This chan 600 to 800 feet in width, but is barred at the foot by a broad limestone reef, is considerable fall and a rapid current. The channel to the right of Wood from 175 to 250 feet in width; the reef at the foot is nearly absent and th nearly uniform; the bottom seems to be gravel overlying rock. This chan advantageously situated for the proposed improvement.

The general appearance and character of these shoals are similar to those cle Shoals in the Tennessee River. The reefs, as a rule, present their upstu to the current, and are generally of sandstone. The shoal above Wood's Is from 1,400 to 1,800 feet in width.

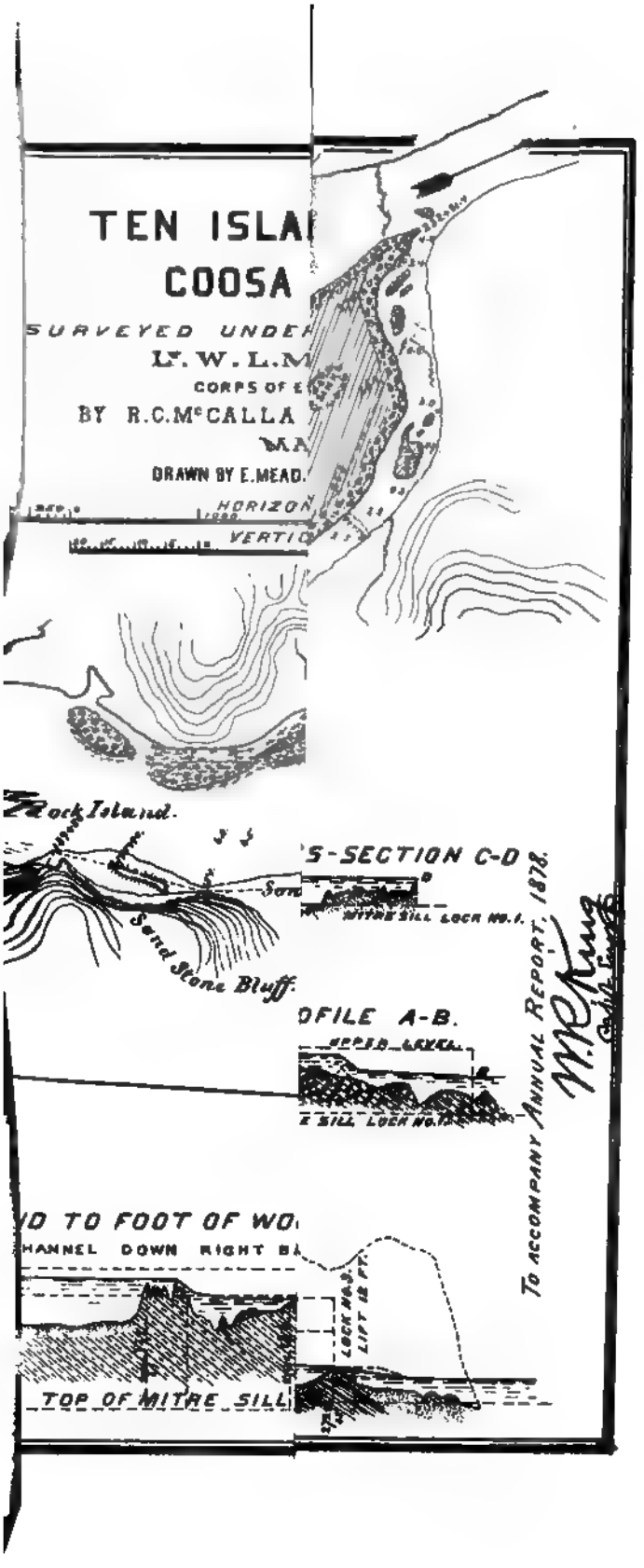
The banks in the immediate vicinity of both shoals (except below the head Island on the right) are steep hill-slopes of loose rock and earth, with occa points and bluffs. There are no benches and berms near the water's edge, b slopes run down to the rock bottom of the river. Above and below each between them, are small tracts of bottom-lands, which are overflowed at ext water. Between these two shoals the banks are low, and there are about 3 rich cultivated land, which would be overflowed if an attempt were made t the upper fall by a dam near the head of the Ten Islands Shoal.

At the head of the Ten Islands Shoal, the evidence afforded by drift sho usual floods do not exceed from 4 to 5 feet. Two-thirds the length of Wo below its head, the height of the flood of February, 1875—the highest k been marked on a tree, and shows a rise of little over 16 feet, but this was water from below where the mountains narrow the area of discharge and stream. At Greensport, above the head of Whistenant's Shoal, this flood feet above low-water. Floods of 8 feet rise are very unusual, and rises of rare.

At many points along the shoals there is an abundance of sandstone of tol quality for masonry, and sufficient limestone near by for the more exposed tant parts of locks. The whole country is thickly clothed with fine long-l timber, or, if preferred, a sufficient quantity of white oak, post-oak, elm, hard woods can be procured for the proposed improvement, but would be co more expensive because more rare.

Malarial diseases, such as chills and fevers and bilious disorders, will int the work, as at the Muscle Shoals of the Tennessee River.

PROPOSED IMPROVEMENT.


TEN ISLA
COOSA
SURVEYED UNDE
Lt. W. L. M
CORPS OF E
BY R.C.McCALLA
DRAWN BY E.MEAD.
HORIZON
VERTIC
Rock Island.
Sand Stone Bluff.
S-SECTION C-D
MITRE SILL LOCK NO. 1.
OFILE A-B.
UPPER LEVEL
E SILL LOCK NO. 1.
D TO FOOT OF WO
HANNEL DOWN RIGHT B
LOCK NO. 3. LIFT 12 FT.
TOP OF MITRE SILL
TO ACCOMPANY ANNUAL REPORT, 1878.
W. R. King

hollow quoins and along the face of the lock of 10 feet. The rest of the lock-masonry to be of dry stone. The coping, hollow quoins, facing of the miter-sills, and one side of the lock-chamber from water-surface of lower level at low-water to the coping to be of cut stone, the rest of rubble.

The lock to be 210 feet between miter-sills and 40 feet wide, to accommodate the steamers which now navigate the Upper Coosa. The reefs to be excavated to a depth of 3 feet at extreme low-water or 4 feet at ordinary low-water, and for a channel width of 80 feet. When the river rises 5 feet or more, the fall is so far obliterated that boats can use the natural water-way.

ESTIMATE.

Lock:	
439 cubic yards cut stone, at $14	$6,126 00
2,004 cubic yards rubble, at $7	14,028 00
474 cubic yards dry stone, at $4.50	2,133 00
301 cubic yards slope wall, at $3.50	1,053 00
Lock-pit:	
1,534 cubic yards rock excavation, at $2	3,068 00
200 cubic yards excavation and embankment, at 30 cents	600 00
Lock-gates and machinery	2,000 00
Channel excavation, 1,440 cubic yards rock, at $3	4,320 00
Dam:	
1,400 feet crib-dam, at $7.25	10,150 00
Total	43,478 00

TEN ISLANDS SHOALS.

It is proposed to utilize the Wood's Island chute as a canal by placing at its foot a lock of 12 feet lift and a dam 250 feet long, to connect Wood's Island with the tow-head above it by a slope walled earthern embankment 300 feet long, 10 feet high, 10 feet wide on top, with protected slopes of 1 upon 1; to extend a similar embankment upstream from the head of this tow-head about 600 feet, where a lock of 5.77 feet lift with guard-walls allowing navigation up to a 7-foot flood, and a dam 8½ feet high and 1,400 feet long across the Coosa River is to be placed.

The locks will be of similar construction to that at Whistenant's mill, and of about the same dimensions and height of guard-walls. The dam to be built with a crib-base of 12 by 12 inch timber, 14 feet wide and 4 feet high, filled with stone and planked in front with 2½ inch plank, the upper 4½ feet to be triangular framed, resting upon this crib-base and bolted to it, its top with a slope of ½, and doubly planked with 2-inch plank; this will give an apron 5 feet wide, to partially break the force of the overfall. This form of dam is proposed on account of the rough nature of the bottom of the river.

The lower lock is to have 3 feet over the lower miter-sill at extreme low-water, or 4 feet at ordinary low water.

The upper lock to have 5 feet of water over sill. This will give a commodious canal from 100 to 250 feet wide nearly 2 miles long, with from 5 to 10 feet of water throughout.

ESTIMATE OF COST.

1. Lock No. 2, as at Whistenant's Shoal, masonry and gate			$25,340 00
Lock-pit: 1,390 cubic yards rock excavation, at $2	$2,780 00		
1,000 cubic yards gravel excavation, at $1	1,000 00		
2,500 cubic yards earth excavation and embankment, at 30 cents	750 00		
Total			4,530 00
2. Lock No. 3, as above			25,340 00
Lock-pit: 2,000 cubic yards rock excavation, at $2	4,000 00		
1,600 cubic yards gravel excavation, at $1	1,600 00		
2,200 cubic yards earth excavation and embankment, at 30 cents	660 00		
		6,260 00	
3. Dam at foot of Wood's Island, 250 feet long, at $25			6,250 00
4. Dam across Coosa River:			
Lumber, 300,000 feet, board measure, for cribs, at $20 per 1,000 feet, placed	6,000 00		
Iron, 12,775 pounds, for drift-bolts, at 10 cents per pound, placed	1,277 50		
Rock, 3,300 cubic yards, placed in dam, at $3 per cubic yard	9,900 00		
Masonry, dry, 240 cubic yards, placed in abutments, at $5 per cubic yard	1,200 00		
Total			18,377 50

5. Earthen tow-path embankment:		
7,407 cubic yards embankment, at 40 cents	$2,962 80	
1,480 cubic yards, slope-wall, at $2.50	3,700 00	
Total		$6,662 80
6. Channel excavation—rock:		
Rock Island Reef, 648 cubic yards, at $3	1,944 00	
McConnel's Reef, 1,229 cubic yards, at $3	3,687 00	
Total		5,631 00
Total for Ten Islands Shoals		97,991 30
Or for the improvement of both shoals		141,469 30
Add 10 per cent for contingencies		14,146 93
		155,616 23

Respectfully submitted.

W. L. MARSHALL,
First Lieutenant of Engineers.

Capt. W. R. KING,
Corps of Engineers, U. S. A.

S 5.

IMPROVEMENT OF OOSTENAULA AND COOSAWATTEE RIVERS.

No work was done on either of these rivers during the year, the entire balance of the appropriation having been expended in the fiscal year 1876 and '77.

An appropriation having been made June 18, 1878, advantage will be taken of the low water season to repair and extend some of the wing-dams, and otherwise continue the system of improvements made under former appropriations.

Original estimates, made for these rivers, are	$28,208 50
Amounts appropriated	19,000 00
Amounts expended	19,000 00

Money statement.

Amount appropriated by act approved June 18, 1878	$4,000 00
July 1, 1878, amount available	4,000 00
Amount (estimated) required for completion of existing project	9,208 50
Amount that can be profitably expended in fiscal year ending June 30, 1880.	9,208 50

S 6.

IMPROVEMENT OF ETOWAH RIVER, GEORGIA.

As stated in my last report, an examination of this river was made by Lieut. W. L. Marshall, Corps of Engineers, with a view to ascertaining whether any, and if so, what work could be advantageously commenced with the existing appropriation; and it was respectfully recommended that, in view of the inadequacy of the existing appropriation to accomplish any useful improvement, an instrumental survey of the river be made, upon which to base a specific project for the improvement. A special appropriation for this purpose having been made, the survey will be made, and the project submitted as soon as practicable.

Amount appropriated (act August 14, 1876)	$10,000 00
Amount expended	59 73

Money statement.

July 1, 1877, amount available	$10,000 00
July 1, 1878, amount expended during fiscal year	59 73
July 1, 1878, amount available	9,940 27

S 7.

IMPROVEMENT OF OCMULGEE RIVER, GEORGIA.

This work has been continued during the year by hired labor under the immediate direction of Mr. B. W. Frobel, assistant engineer.

The obstructions to be removed are generally caused by snags and overhanging trees, which either cause direct obstructions, or produce them indirectly, by causing abrupt bends or the formation of sand and gravel bars. The removal of these snags and sunken logs is found to cause the rapid washing away of the bars, and in some cases, as at Reuben's Cut-off, the river has been straightened and shortened several hundred yards by pulling out the stumps and fallen trees in a natural cut-off, which was immediately deepened by the water, so as to form a practicable channel 7 or 8 feet deep at low water.

Four hundred and twenty snags, measuring from 2 to 4 and some even reaching 5 feet in diameter, and 360 overhanging trees, were removed during the year. This work is in an exceedingly isolated location, and communication with the working parties is therefore very inconvenient.

This work is in the collection district of Brunswick, Ga.

Number of vessels sailing from the port of Darien, Ga., from January 1, 1877, to January 1, 1878, was 217; aggregate tonnage, 106,369.

Principal export, lumber, feet, 86,606,952; estimated value, $853,777.

The original estimate of the cost of the work of improving this river is $56,240.

Amounts appropriated	$30,000 00
Amount expended	13,012 69

Money statement.

July 1, 1877, amount available	$14,953 33	
Amount appropriated by act approved June 18, 1878	15,000 00	
		$29,953 33
July 1, 1878, amount expended during fiscal year	12,966 02	
July 1, 1878, outstanding liabilities	484 55	
		13,450 57
July 1, 1878, amount available		16,502 76
Amount (estimated) required for completion of existing project		26,240 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		26,240 00

S 8.

IMPROVEMENT OF OCONEE RIVER, GEORGIA.

An appropriation of $10,000 having been made for the improvement of this river (act of June 18, 1878), a preliminary examination has been made which shows that in general character the work required will be similar to that on the Ocmulgee, and preparations are being made to begin *active operations* as soon as possible.

The principal object of this improvement is to furnish an outlet for the commerce which naturally centers at Dublin, a town completely isolated from railroad communication, and dependent entirely upon wagon and river transportation (see Report of Chief of Engineers, 1875, Part II, page 44).

Estimated cost of work to be done is $10,150. The sum of $10,000 has been appropriated.

Mr. B. W. Frobel, assistant engineer, reported to this office March 4, that $15,000 is needed, stating that—

This estimate exceeds that given by Assistant Engineer Gould (see report Chief of Engineers, 1875, Appendix W) by some $5,000. This is caused by adding cost of steam-tender or tow-boat omitted in Mr. Gould's estimate, but which will be absolutely necessary on this work.

Money statement.

Amount appropriated by act approved June 18, 1878	$10,000 00
July 1, 1878, amount available	10,000 00
Amount (estimated) required for completion of existing project	5,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880	5,000 00

APPENDIX T.

ANNUAL REPORT UPON THE WORKS IN CHARGE OF MAJOR G. WEITZEL, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1878, BY CAPTAIN ALEXANDER MACKENZIE, CORPS OF ENGINEERS, TEMPORARILY IN CHARGE.

UNITED STATES ENGINEER OFFICE,
Detroit, Mich., July 10, 1878.

GENERAL: I have the honor to transmit herewith the annual reports relating to the river and harbor improvements temporarily under my charge, for the fiscal year ending June 30, 1878.

Very respectfully, your obedient servant,

A. MACKENZIE,
Captain of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

T 1.

IMPROVEMENT OF THE FALLS OF THE OHIO RIVER.

The history and condition of work done on this improvement during the past fiscal year are given in the following report of Capt. A. N. Lee, Corps of Engineers, who is in immediate charge of the work:

LOUISVILLE, KY., *June* 30, 1878.

SIR: I have the honor to submit the following report on the improvement of the Falls of the Ohio and the enlargement of the Louisville and Portland Canal for the fiscal year ending June 30, 1878.

The work projected at the beginning of the year was as follows: To complete the rock-excavation at the head of the canal; to complete the cross-dam at the head of the falls, leaving an opening of 600 feet opposite the Indiana Chute for the benefit of descending navigation; to make a new opening of 400 feet at the head of the middle channel to benefit ascending navigation at certain stages of the river; to close 400 feet of the Indiana opening and the entire middle opening with movable dams, thus leaving an opening of 1,000 feet during high water and closing this opening to 200 feet during low water, when the falls are not available for ascending boats; to remove the worst obstructions in the Indiana Channel over the falls.

On the 17th of August, 1877, the stage of the river was such as to justify getting tools and machinery ready, and ten days later the building of the coffer-dam around the rock at the head of the canal was commenced. Though work on the coffer-dam was several times delayed, and portions injured by the waves of passing steamers, it was so far completed by September 24 that the rock-excavation could be commenced.

Work was carried on day and night, and at 11.25 a. m. on the 11th of November the last yard of stone was removed, thus completing a work which, owing to unfavorable stages of water and lack of funds, has extended through many years. A few hours after the completion of this work the rapidly-rising river flooded the dam.

During September, October, and November the cross and wing dams were repaired, and the cross-dam was extended 128 feet.

No further extension of this dam should be made until the new opening is made at the head of the middle channel and a few of the worst obstructions in the Indiana Channel removed.

To ascertain the cost and practicability of building a coal-chute over the falls, a detailed survey of certain portions of the river-bed was made. Before this survey could

be extended to the Indiana Chute high water drove off the party, but a complete and detailed map of the middle channel has been prepared. In October preparations were made for removing some of the worst obstructions at the head of the Indiana Chute, with a special view of obtaining data upon which to found correct estimates of the cost of extending this work. With the co-operation of Captains Lockhart and Varble, falls pilots, those points were selected for work which would, with a small expenditure of money, give the greatest amount of relief. After anchoring above the reefs boats to work from, and placing triangular breakwaters to uncover rocks, a rise in the river stopped the work.

The following is a summary of the work accomplished during the year: 1,356 linear feet of coffer-dam 10 feet wide and averaging 8 feet in height was built; 5,659 cubic yards of stone, 817 cubic yards of earth, and a wrecked iron barge were removed from inside the coffer-dam.

The cross-dam at the crest of the falls was extended 128 feet, and both wing and cross dams were repaired.

The total expenditures for the year was $32,054.01, divided among the works as follows:

5,659 cubic yards rock-excavation, at $3.71	$21,105 17
817 cubic yards earth-excavation and removal of wreck of iron barge, at $4.44	3,624 32
128 linear feet of cross-dam, at $19.42	2,485 47
Repairs on wing and cross dams	3,331 04
Survey of the falls	997 42
Contingencies of engineering, office expenses, &c	510 59
Total	32,054 01

The cost per foot for cross dam was greater than during the previous years, the dam being higher, the depth of water being greater, and the current more swift.

The cost of the rock-excavation was increased by the accidents to the coffer-dam, the large amount of deposit and the old wreck included in the stripping, and the necessity for pressing the work with a very large force day and night.

But with all this the cost of removing a cubic yard of rock as done by days' labor was $1.96 less than the lowest bid made for the work in 1873, thus saving $20,329.12 to the government. There now remains available of the $100,000 appropriated in 1875, $47,360.67, and with this amount the following work will be commenced and as much as possible completed, when low water permits. Work will be carried on economically.

A movable dam, 400 feet long, will be built parallel with and about 50 feet below the permanent dam, opposite the middle channel of the falls. When this dam is completed 400 feet of the permanent dam will be removed.

Some of the worst obstructions in the Indiana Channel will be removed and estimates made for the removal of other obstructions.

The cross-dam on the crest of the falls will be protected from the injurious effects of ice and drift, and the dam will be extended 185 feet, reducing the Indiana opening to 600 feet.

It is not probable that the closing of 400 feet of this opening with a movable dam can be attempted with the balance on hand, but the necessity for this will not be felt until the general improvement of the Ohio gives a minimum depth of 6 feet throughout the year.

Very respectfully, your obedient servant,

A. N. LEE,
Captain of Engineers.

Capt. A. MACKENZIE,
Corps of Engineers, U. S. A.

This improvement can only be carried on economically during low water, but fortunately the work, while necessary, is not of such imperative necessity as to require the extravagant expenditure which would attend work attempted during high water.

The rock-excavation at the head of the Louisville and Portland Canal, which was commenced in October, 1873, was completed during the past season. This work has been done by days' labor, and its total cost has been much less than it would have been had the bids of contractors been accepted when the work was advertised in April and June, 1873.

By the completion of this work the entrance to the canal has been widened and greatly improved.

The cross-dam on the crest of the falls was, during the season, extended 128 feet, reducing the opening opposite the Indiana Chute to 782 feet.

While this last extension has increased the depth of the water at the head of the pass and improved descending navigation, it has so increased the current as to increase somewhat the difficulty of ascending this pass. But this is a matter of little importance, as but a few powerful boats are able to make this ascent during the brief period in which the extension materially affects the current.

A new and much better channel for boats able to ascend the falls will soon be provided.

A detailed survey of the channels over the falls was commenced during the season, but owing to high water was not completed. The object of this survey was to determine the cost and feasibility of building an additional canal or coal-chute over the falls.

An attempt was also made to remove a few of the worst obstructions in the Indiana Chute. The river rose rapidly after commencing the work, and but little was accomplished. It is not proposed to devote much of the present appropriation to this work, for it has never yet been demonstrated that the results to be obtained from an extensive improvement of this channel will be commensurate with the cost of the work. Enough work will be done to determine, in connection with the survey, this question.

There remains unexpended of the appropriation made in 1875 $47,360.67, and the following project for the expenditure of this money has been approved: To make a new opening of 400 feet in the cross-dam on the crest of the falls at the head of the middle channel, and to close this opening with a movable dam, which can be closed during low stages of the river. To extend the cross-dam 182 feet, reducing the Indiana opening to 600 feet. To plate the upper portion of the cross-dam with iron. To continue the survey and examination of the channels over the falls, and remove a few of the worst obstructions in the Indiana Channel.

Since plans for completing the enlargement of the Louisville and Portland Canal and improving the navigation of the falls were presented and approved in 1867, various modifications in details have been authorized, as experience suggested them; but with all these changes the general idea has been kept in view, that the only radical method of improving the navigation of the falls was by building around or over them, and that all other means of rendering assistance were secondary in importance.

It will never be practicable to do away entirely with delays at the falls, for it must be remembered that the rocks forming the obstructions were placed in the river by nature, and that by no human means can navigation at this point be rendered as easy and rapid as in the unobstructed river. These delays should be considered relatively. At one time they were indefinite, navigation being suspended except during the brief period of high water. At a later date they were reduced by building a canal; since the canal has been enlarged the delays have been, as compared with former times, insignificant.

In the future, when the business of the river will warrant it, and delays become very serious, additional canals must be built.

In the meanwhile, it is well the work should be continued as at present, gradually completing and improving, as far as cost will justify, all existing channels, and obtaining at the same time data for future additional aids to navigation.

The reasons for the exceeding of the original estimate for this work has been given in previous reports. The excess in cost as far as enlarging the canal is concerned was caused entirely by the manner in which appropriations were made.

As regards the dams and accessory works of improvement, slight modifications in the plans have affected the cost.

The original estimate for this work was $1,243,500. There has been allotted and appropriated for it as follows:

1868, allotted	$85,000
1869, allotted	178,200
1870, appropriated	450,000
1871, appropriated	250,000
1872, appropriated	300,000
1873, appropriated	100,000
1875, appropriated	100,000
Total	1,463,200

Of this amount, $1,415,839.33 has been expended.

No additional appropriation is required for the next fiscal year.

The work is located in the third collection-district of Kentucky. The nearest port of entry is Louisville, Ky.

The amount of revenue collected at this port during the fiscal year was $55,033.50.

The commerce and navigation of the Mississippi River and all its branches will be benefited by the completion of this work.

Money statement.

July 1, 1877, amount available	$82,650 66
July 1, 1878, amount expended during fiscal year	35,290 66
July 1, 1878, amount available	47,360 00

T 2.

SUPERINTENDENCE, MANAGEMENT, AND REPAIR OF THE LOUISVILLE AND PORTLAND CANAL.

The annexed report of Capt. A. N. Lee, Corps of Engineers, gives in detail the history and condition of the work during the past fiscal year.

The repairs and improvements necessary for placing and keeping the canal and its accessories in perfect working order have been continued as in former years.

The rules and regulations for the government of the canal and those using it, referred to and given in previous reports, were approved by the Secretary of War. They have been published for the benefit of all concerned, but as no penalties are as yet attached to the violation of these rules, it may be impossible in some cases to enforce them.

Authority has been granted for converting the three chambers of the old locks into two, building new gates, and otherwise placing these locks in good working order. This work has been commenced and will be continued when low-water permits. This improvement will greatly assist in the passage of coal-tows, and the old locks so converted will accommodate all boats running during the low-water season, permitting the closing of the new locks for repairs.

The business of the canal continues to increase, and already demands are made for increased accommodations, but the apparent necessity for this at present is due to the accumulation of business during coal-runs. If this business were distributed throughout the year, the canal has sufficient capacity to accommodate all comers without any appreciable delay.

In January, tolls were reduced about one-fifth; but notwithstanding this reduction the receipts have continued to be in excess of the expenses,

and it is almost certain that a further reduction can be made next January.

To satisfy a demand frequently made, there is added to this report a historical and descriptive sketch of the Louisville and Portland Canal, with 10 plates.

Annexed hereto is the financial statement for the fiscal year ending June 30, 1878.

Financial statement for fiscal year ending June 30, 1878.

Expenditures.		Deposits.	
Months.	Amounts.	Months.	Amounts.
1877.		1877.	
July	$60 16	July	$9,631 25
August	8,716 88	August	3,798 59
September	1,239 55	September	1,957 20
October	9,994 24	October	1,930 00
November	6,167 88	November	9,498 95
December	5,358 64	December	14,364 02
1878.		1878.	
January	6,720 68	January	13,108 73
February	4,397 69	February	8,260 00
March	533 05	March	7,566 76
April	9,155 58	April	8,778 68
May	4,500 89	May	12,545 75
June	5,358 46	June	7,670 93
	62,203 70		99,110 86

Cash on hand June 30, 1878, $81,739.78.

REPORT OF CAPTAIN A. N. LEE, CORPS OF ENGINEERS.

LOUISVILLE, KY., *June* 30, 1878.

SIR: I have the honor to submit the following report on the superintendence, management, and repair of the Louisville and Portland Canal for the fiscal year ending June 30, 1878.

Part of this report must necessarily be a repetition of that submitted at the close of the last calendar year.

WORK ACCOMPLISHED ON THE NEW CANAL.

The new guard-gates for the head of the canal which were under process of construction at the date of the report for the last fiscal year were completed and placed in position by December 20; they cost $4,572.76, and the building of them under the immediate direction of the superintendent of the canal has resulted in having the work admirably done, as well as saving several thousand dollars.

New winding-drums have been put in at the middle and lower gates and gearing has been added, increasing the power of the capstans and strengthening all parts of the apparatus. The working in both cases has been satisfactory. Two new opening-chains of 1 inch in diameter have been substituted for the old ones at the lower gates, one of Norway and the other of the best Tennessee iron. It is proposed to test their relative durability.

The anchors of the mast-guys have been reset in solid stone and cement. In some cases they were broken and in others loose in their foundation. A large amount of grading and sodding has been done, and the north bank between the upper and middle gates is now in perfect order.

The deposit removed from the lock-wall and bank has been used to fill in the ravine in rear and at side of superintendent's office.

The cistern in rear of office has been entirely covered with this material, connected with the office, and a waste-pipe from one-half of the toll-collector's house. A pump-house has been erected over the cistern and the pump will be placed in position in a few days.

The superintendent's office was completed and occupied by November 21.

The old roadway of the bridge at the new locks has been entirely replaced by a new one, the iron-work painted, and the bridge generally placed in first-rate working order.

On the 18th of September, the water being low and business almost suspended, the canal was closed for repairs for the middle miter sill of the new locks. The work occupied about sixteen days. All broken and injured stones were replaced by hard limestone set in Portland cement, and the repairs made as thorough as possible. The work can, however, only be regarded as temporary, as, when time will permit, the whole sill must be rebuilt. The canal was reopened October 5.

While the water was out, the miter-sill and roller-ways of the guard-gates at the head of the canal were thoroughly repaired.

A wagon-shed has been erected adjoining the stable and the stable thoroughly repaired.

A large shed for the storage of derricks and machinery generally has also been built, and all the canal buildings and fences recolored or whitewashed.

Most of the work above referred to, in addition to numerous minor improvements, ordinary repairs, and regular duties, has been carried on under the immediate direction of the superintendent, and as far as possible the work has been done by the regularly employed mechanics and laborers.

The work done by tow-boats and dredges and by lock hands in passing boats is given in annexed tables.

OLD LOCKS.

Owing to high water, no work has been done on the improvement of the old locks since November 11; previous to that time, however, the lower miter-sill and roller-ways were thoroughly repaired, a large portion of the rock-excavation in the lower chamber made, and the masonry for new gate-recesses had been commenced.

Plans and estimates for the lower and middle gates have been prepared, the timber and iron purchased for their construction, and the work of framing is well under way. The work will be done entirely in the canal shops, and it is believed that the result will show a large saving over contract work, and that the work will be much better done.

NUMBER AND SALARY OF EMPLOYÉS.

The regular canal force remains the same as given in the last annual report, except that the position of foreman of dredges has been done away with, but it has been necessary to employ extra mechanics and laborers from time to time upon works of improvement.

The regular pay-roll of employés now amounts to $37,915. Since the Government assumed control of the canal the pay-roll has been reduced $2,045.

RATES OF TOLL REGULATION.

The reduction in rates of toll recommended in the report of the last calendar year having been approved by the proper authorities, the new rates took effect February 4, 1878.

They are as follows:

Steamboats and model barges, 8 cents per ton.
Square barges, flats, coal-boats, &c., 6 cents per ton.
All empty square barges and coal-boats, 5 cents per ton.
Small boats, $4 each.
Rafts of logs, &c., measurement and rates the same as for coal-boats.
Boats belonging to or chartered by the United States, free.
Towing, harbor rates.
Use of dredge, $2.50 per hour.
Use of steam-pump, $2.50 per hour.
Use of dry-dock, $15 for first day and $10 each subsequent day.

With this reduction, the receipts of tolls for the months of February, March, April, May, and June of this year were $43,549; for the corresponding months of 1877, $45,740.60. This shows a considerable increase in the business of the canal, and that a still further reduction of toll may be made at some future time. This should not be done, however, until all parts of both the old and the new locks are in thorough working order and all works of permanent improvement completed.

RECEIPTS AND EXPENSES.

The receipts for the year have amounted to $99,613.50, being $34,449.95 in excess of expenditures, and $52,620.11 in excess of operating expenses. The expenses during the year have been $65,163.55. Of this amount $18,170.16 was applied to extensive

repairs and improvements of a permanent nature, leaving $46,993.39 as the expense of operating the canal. These operating expenses will seem large if compared with those of other canals, but in making the comparison, it must be borne in mind that the difficulties to be encountered here in moving the gates and the necessary expenses to keep the canal in good working order are much greater than at any other point.

These difficulties arise from the defective manner in which the gates are suspended, their extreme weight, and the immense amount of deposit brought into the canal and lock-chambers. The expense attending the removal of this deposit alone must necessarily be great, as it requires the almost constant employment of a steamboat, 2 dredges, and 4 dump-scows.

WORK PROJECTED FOR NEXT YEAR.

The following work will be attempted during the coming year if money and time are available:

Rebuilding the old locks, converting three chambers into two.

Building three sets of lift-gates and one set of guard-gates for same.

Building one set of lift-gates for new locks.

Moving the bridge crossing the old locks to a more convenient locality.

Changing the method of suspending the gates of the new locks and substituting iron for wooden masts. The present method is very defective and largely increases the cost of working the canal.

Building a sufficient number of cottages on the south bank of the canal to accommodate the lock-hands.

Continuation of grading and sodding of both banks of the canal below the bridge, using the material removed from banks and lock-walls for filling in about the superintendent's office.

Replacing frame engine-house and watch-houses on lock-walls with substantial ones of stone or brick.

Building a new hull for dredge No. 1.

Ordinary superintendence, management, and repairs.

In conclusion, I take great pleasure in testifying to the faithful, just, and efficient manner in which the superintendent and his assistants have performed their duties.

Very respectfully, your obedient servant,

A. N. LEE,
Captain of Engineers.

Capt. A. MACKENZIE,
Corps of Engineers, U. S. A.

Detailed statement of vessels passed through the Louisville and Portland Canal during the fiscal year ending June 30, 1878.

Date.	Passenger boats.		Tow-boats.		Model barges.		Square barges.		Small boats.
	Number.	Under tonnage.	Number.	Under tonnage.	Number.	Under tonnage.	Number.	Under tonnage.	
1877.									
July	79	33, 984	38	5, 887	76	20, 434	208	55, 826	13
August	83	25, 676	38	2, 585	29	5, 256	35	4, 095	19
September	50	10, 811	4	343	9	1, 693	31	5, 808	2
October	64	14, 243	25	1, 510	9	1, 629	37	3, 441	9
November	95	31, 006	45	5, 193	72	16, 737	262	53, 469	44
December	86	34, 343	48	8, 087	69	18, 073	339	110, 799	8
1878.									
January	71	28, 477	51	8, 773	59	14, 801	399	129, 801	11
February	49	22, 408	43	4, 934	29	7, 777	232	72, 288	9
March	58	21, 569	39	6, 482	71	19, 283	239	79, 105	15
April	97	38, 773	50	7, 368	87	22, 158	186	46, 370	6
May	77	30, 903	60	9, 651	105	27, 373	366	117, 390	12
June	86	35, 417	46	7, 116	90	24, 400	193	46, 023	10
Total	895	327, 610	487	67, 929	705	179, 614	2, 527	724, 325	158

Detailed statement of receipts of the Louisville and Portland Canal for the fiscal year ending June 30, 1878.

Number.	Designation.	Number of tons.	Price per ton.	Amount collected.
534	Steamboats	151,392	$0 10	$15,139 [illegible]
361	....do	146,3[illegible]	08	11,704 [illegible]
252	Tow-boats	32,749	10	3,274 [illegible]
235	....do	35,140	08	2,811 [illegible]
324	Model barges	75,903	10	7,590 [illegible]
361	....do	100,711	08	8,056 [illegible]
565	Square barges	250,900	08	20,072 [illegible]
776	....do	236,418	06	14,185 [illegible]
886	....do	237,007	05	11,850 [illegible]
106	Small boats	.....	*5 00	530 [illegible]
52	....do	.....	*4 00	208 [illegible]
				98,[illegible]
	Receipts from rent			[illegible]
	Receipts from dry-dock			230 [illegible]
	Receipts from towing			130 [illegible]
	Receipts from dredging			116 [illegible]
	Total receipts			99,[illegible]

* Each.

NOTE.—This statement includes the amount collected up to 12 p. m. of the night of June 30, 1878, and will, therefore, not agree with the amount of deposits as shown in financial statement.

Detailed statement of expenses for superintendence, management, and repairs of the Louisville and Portland Canal for the fiscal year ending June 30, 1878.

Date.	Lockage department.			Dredge department.			Improvements.	Grand total.
	Labor.	Purchases and repairs.	Total.	Labor.	Purchases and repairs.	Total.		
1877.								
July	$2,384 83	$264 04	$2,648 87	$925 58	$194 80	$1,120 38	$1,172 43	$4,941 68
August	2,330 00	230 01	2,560 01	915 00	261 85	1,176 85	1,368 13	5,104 99
September	2,205 00	1,083 71	3,288 71	900 00	235 82	1,135 82	1,417 42	5,841 95
October	2,286 00	1,101 71	3,387 71	852 00	170 16	1,022 16	2,178 12	6,587 99
November	2,247 52	814 05	3,061 57	821 34	203 98	1,025 32	1,084 66	5,171 55
December	2,697 59	147 97	2,845 56	820 00	223 76	1,043 76	503 56	4,392 88
1878.								
January	2,639 66	316 52	2,956 18	820 00	271 75	1,091 75	3,137 63	7,185 56
February	2,552 25	119 84	2,672 09	835 00	373 91	1,208 91	81 17	3,962 17
March	2,601 43	148 42	2,749 85	835 00	192 37	1,027 37	554 33	4,331 55
April	2,375 00	181 97	2,556 97	835 00	300 70	1,135 70	1,071 20	4,763 87
May	2,375 00	253 87	2,628 87	861 75	178 99	1,040 74	1,795 18	5,464 79
June	2,375 00	226 24	2,601 24	835 00	172 00	1,007 00	3,806 33	7,414 57
Total	29,069 28	4,888 35	33,957 63	10,255 67	2,780 09	13,035 76	18,170 16	65,163 55

NOTE.—This statement shows the expenses of the month in which they were incurred, and will therefore not agree with the amount of expenditures as given in financial statement.

HISTORICAL AND DESCRIPTIVE SKETCH OF THE LOUISVILLE AND PORTLAND CANAL.

A mass of rocks in the bed of the Ohio River opposite Louisville, Ky., forms a series of obstructions known as the Falls of the Ohio. The bed of the river at this point has a fall of 26 feet in a distance of about 2 miles, four-fifths of this fall being within a distance of about 1 mile.

The river rises and falls more rapidly below than above the rapids, the difference of level being 26 feet during low water and but 18 inches when the river is high.

The falls or rapids are impassable during a large portion of the year, and at all other

times except when the river is very high, navigation over them is difficult and dangerous.

As early as the year 1802 the expense and delay attending the reshipment of freight around the falls from the Lower to the Upper Ohio had become so serious that numerous plans were proposed for overcoming the obstruction, but no active measures were taken until the year 1825, when a stock company obtained a charter from the legislature of the State of Kentucky, authorizing them to construct a canal around the Falls of the Ohio within the State of Kentucky.

This canal was completed and the first boat passed through December 22, 1830, though many subsequent improvements were made. As originally constructed the canal was 1.9 miles long, 64 feet wide, and had at its lower end three lift-locks (combined), each 198 feet long, between miter-posts, with available length of 185 feet, 50 feet wide, with lift of 8¾ feet.

The final estimates of the engineer in charge on the amount of work done were as follows: Earth excavation, 615,249 cubic yards; rock excavation, 162,551 cubic yards; embankment, 133,203 cubic yards; masonry, 27,713 perches of 25 cubic feet; pavement, 113,635 square yards.

The average prices paid for work were as follows: For earth excavation, 15 cents per cubic yard; for rock excavation, $1.50 per cubic yard; for masonry, $12.37 per perch; for paving slopes, 1 foot thick, 15 cents per square yard. The company were at the additional expense of furnishing and working a steam-pump, when necessary.

The total cost of the work, including the purchase of land and building canal, was $1,019,277.09.

In 1830, when the canal was completed, its dimensions were thought to be sufficient for all time, but gradually the size and model of steamboats were so changed that in 1852 but fifty-seven one-hundredths of the tonnage engaged on the western waters could pass through the locks.

The aid of Congress was invoked from time to time, and in 1842 an elaborate memorial was presented, setting forth the inadequacy of the Louisville and Portland Canal and asking for an appropriation for its enlargement.

The evident necessity for an enlargement, as well as the demand of the public for a reduction of the heavy rates of toll, induced, in many of the stockholders, the opinion that the canal should be held by the United States, enlarged, and made free. With a view to this, the Kentucky legislature, in January, 1842, upon petition of the Louisville and Portland Canal Company, amended the charter to admit of liquidating the stock and ultimately making the canal free. The president and directors were authorized to sell the stock held by individuals to the United States, the State of Kentucky, or the city of Louisville, or further to appropriate the net income of the canal to the purchase of stock belonging to individuals instead of making dividends therewith, and it was further provided that the shares so purchased should be held in trust by said directors until the whole belonging to others than the United States should be liquidated, and when all were so purchased the said shares should be transferred to the United States on condition that the government should levy tolls only sufficient to keep the canal in repair and pay all necessary expenses for custody and superintendence and make all necessary improvements so as to fully answer the purposes of its establishment and protect the interests of commerce. This amended charter was accepted by the stockholders July 4, 1842. The United States, one of the stockholders, was represented by an agent, who verbally accepted the amendment, but having no instructions from the Secretary of the Treasury, did not have his vote recorded.

In February, 1844, the Kentucky legislature amended the act of January, 1842, by enacting that in the event of the United States becoming the sole owner of the canal, the jurisdiction of the commonwealth over the said canal would be yielded up to the Government of the United States, and no reports would be required to be made to the general assembly. It was in accordance with this amendment that the government finally took possession of the canal.

When the necessity for an enlargement became apparent and the tolls became a burden on western commerce, it was natural for those interested in the river traffic to look to Congress for relief; for not only was the canal a part of a national highway, but the United States, being a large stockholder, had derived a profit from the tolls collected.

In June, 1825, Congress authorized the subscription for 1,000 shares of stock, and in 1829 again authorized a subscription for 1,335 shares, which had been forfeited by individual stockholders for want of confidence in the enterprise.

In December, 1831, 567 shares of stock, representing interest accrued, were issued to the United States. In all, the government owned 2,902 shares, which had cost but $233,500. From 1832 to 1842 the government received as dividends from tolls imposed on the commerce of the West, $257,778. During the same time there was paid to private stockholders $564,716.

In 1855, after all individual shares had been purchased, excepting 5 shares held by

the directors at the request of the Secretary of the Treasury, the stock stood as follows:

Held by directors individually, 5 shares.
Held by directors in trust for the United States, 7,093 shares.
Held by the United States, 2,902 shares.

The United States had, therefore, without expense acquired 9,995 shares of stock, and in consequence of the refusal of Congress at this time to accept the canal as a government work, on the conditions imposed by the Kentucky legislature, its management remained in the hands of five directors of the canal company.

Despairing of government aid, the directors, in 1856, at the suggestion of the Secretary of the Treasury, prepared plans for enlarging the canal, and an act was obtained from the Kentucky legislature authorizing the directors to appropriate the revenue and pledge the credit of the company for the enlargement of the canal. On the 24th of May, 1860, Congress ratified this authority with the proviso that the president and directors of the company should in no way use or pledge the faith or credit of the United States, and that when the enlargement was completed and paid for no more tolls should be collected than an amount sufficient to keep the canal in repair and pay necessary expenses of superintendence and management.

The directors immediately raised money by issuing bonds, purchased land, and engaged the services of Mr. T. R. Scowden, a distingnished hydraulic engineer, under whose directions detailed plans were prepared and the work of enlargement was commenced. The war of the rebellion so increased the cost of labor and material that the original estimates were greatly overrun, and in 1866, after expending $1,825,403, work was necessarily suspended.

By joint resolution of Congress approved March 29, 1867, the Secretary of War was directed to cause to be made by an officer of the engineers, surveys and estimates for a ship-canal around the Falls of the Ohio on the Indiana side of the river; also to cause to be made by the same officer estimates for completing the Louisville and Portland Canal on the Kentucky side of the river.

From these examinations and surveys it was concluded that whatever other work might be necessary, the Louisville and Portland Canal should be immediately completed. Upon the recommendation of the Chief of Engineers, United States Army, approved by the Secretary of War, an allotment was made in 1868 for continuing the enlargement of the canal.

The condition of the work at this time was as follows:

The masonry work of the new locks and upper guard-gates was finished, excepting new miter-sills of locks, the stones for which were on hand but not placed.

The bridges were built.

The timber for the gates was on hand and partly framed.

The machinery for moving the gates was partly finished, but not delivered.

Below the locks a rock ledge obstructed the entrance to the canal.

The lock-chambers and space from the locks to the river were almost entirely filled with sediment, and willow trees three inches in diameter were growing in the locks.

A portion of the excavation in the branch canal and large basin was done, but a heavy bank of earth still separated the new branch from the old canal.

A small portion of the earth excavation along the south bank for widening the canal had been made and the earth excavation for the turn-out basin had been almost completed.

The work determined on for completing the enlargement and improving navigation was as follows:

To build an apron-dam at the eastern end of the canal in continuation of the north bank about 1,800 feet long, to prevent boats being drawn onto the rocks.

To build a cross-dam on the crest of the falls with a sufficient height to secure 6 feet of water in the canal during low stages of the river. This dam rendered unnecessary 3 feet of rock-cutting in the canal and effected a saving of about $300,000.

To build a dam below the falls from the head of Sand Island to the Indiana shore, and throw all the water during low stages south of the island and near the mouth of canal.

To build a high-water channel in the river through the outer half of the draw in the railroad-bridge, for the accommodation of boats when the river was so high that they could not pass under the bridge through the wide span without lowering their chimneys.

To remove the rock ledges in the river at the foot of the canal and at the head along the apron-dam.

To complete the new locks, lay miter-sills, build and hang gates, set up machinery, remove deposits, and put locks in working order.

To complete the new branch canal, and widen the old canal 22 feet, by removing earth and solid rock.

To build a cut-stone wall for the protection of the south bank and a portion of the north bank.

To grade and protect the earthen parapets rising above the side walls of the canal.

Under the direction of the Chief of Engineers, United States Army, the work above mentioned was commenced in 1868, and continued from year to year, as rapidly as the appropriations made by Congress would permit.

The new and enlarged canal, though still incomplete, was thrown open to navigation February 26, 1872, and in November, 1873, the work of enlargement was virtually completed.

The following are the totals of work accomplished by the United States. The work done by the company is not included:

Canal proper.—Timber used, 51,370 feet, board-measure; iron, 235,435 pounds; rock excavation, including old wall removed, 140,121 cubic yards; earth excavation, 241,858 cubic yards; masonry, 42,516 cubic yards; filling, 9,473 cubic yards.

This work was done by contract, and the prices paid were as follows: pine timber, $70 per thousand feet; oak timber, $60 per thousand feet; cast iron, 7½ cents per pound; earth excavation, 60 cents per cubic yard; rock excavation, $2.14 per cubic yard; removing old wall, $1.05 per cubic yard; dry wall, $9.91 per cubic yard; cement masonry (not including backing), $8 per cubic yard.

High-water channel.—Earth excavation, 42,710 cubic yards; dry wall, 3,776 cubic yards; filling behind wall, 2,177 cubic yards. The price paid for earth excavation was 39¼ cents per cubic yard, and for masonry $4.95 per cubic yard.

Sand Island dam and head of Sand Island.—Earth excavation, 3,452 cubic yards; riprap, 11,922.41 cubic yards; masonry, 2,543 cubic yards. The prices paid were, for earth excavation, 50 cents per cubic yard; for riprap, $3 per cubic yard; and for masonry, $9.50 per cubic yard.

Rock ledge at head of canal.—10,372 cubic yards were removed at an average cost of $6.08 per cubic yard.

Rock ledge in the river below the canal.—Fffteen hundred cubic yards were removed at a cost of $9.32 per cubic yard.

There was allotted to this work, from appropriations by Congress, including $100,000 appropriated in 1875, $1,463,200, making the total cost of this work, including original cost of canal, the amount expended by the old company, and the amount expended under the direction of the Corps of Engineers, about $4,250,000. Of this amount the government furnished, including bonds assumed, about $2,500,000, the balance being paid for by a tax on the river commerce in the form of tolls.

After the completion of the enlargement in 1873, the management of the canal remained in the hands of the directors of the old company until June 11, 1874.

On the 11th of May, 1874, an act of Congress was approved providing for the payment of the outstanding bonds of the company, and the Secretary of the Treasury was authorized to purchase the 5 shares of stock held by the directors of the company. The Secretary of War was directed to take possession of the canal as the property of the United States, as provided for in the act of the Kentucky legislature approved February 22, 1844.

On the 11th of June, 1874, the Secretary of War took possession of the canal, placed its superintendence, management, and repair under the immediate charge of the Chief of Engineers, and reduced the tolls to an amount barely sufficient for paying the current expenses and making necessary repairs and improvements.

Though Congress failed to respond to the many appeals made in behalf of the Louisville and Portland Canal between the years 1830 and 1868, it caused during this time several surveys and examinations to be made.

In 1843, in accordance with a resolution of Congress, Captain Cram, Corps of Engineers, submitted a detailed report upon the Louisville and Portland Canal and the improvement of the falls. This report is printed in Ex. Doc. No. 243, Twenty-eighth Congress, first session.

In 1845, Lieutenant-Colonel Long, in pursuance of instructions from the Bureau of Topographical Engineers, made an examination of the falls and prepared plans for their improvement.

In 1853, in accordance with joint resolution of Congress, a board, consisting of Brevet Lieutenant-Colonel Long and Brevet Col. William Turnbull, of the Topographical Engineers, and Charles B. Fisk, esq., made an examination and report upon the expediency of building a new canal around the falls and the advantages and disadvantages of canals on the Indiana and Kentucky shores of the Ohio River. Also the cost of enlarging and extending the Louisville and Portland Canal. This report is printed in Ex. Doc. 42, Thirty-second Congress, second session.

In 1867, in accordance with joint resolution of Congress approved March 29, 1867, Maj. G. Weitzel, Corps of Engineers, was charged with a survey and examination already referred to. The report on this work will be found in the Report of the Chief of Engineers for the year 1868.

The present canal leaves the Ohio River above the falls at a point opposite Eighth street, runs in a westerly direction in front of the city of Louisville, and enters the river opposite Sand Island a short distance above Portland, Ky., and below all permanent obstructions to *navigation*.

An apron-dam, 1,800 feet long, facilitates the entrance to the canal and prevents boats being drawn on the rocks at the head of the falls. A crib wing-dam extends from near the head of the apron-dam along the crest of the falls with suitable openings for passing boats.

The length of the canal, including the new branch, is 2¼ miles, and the widths are at upper entrance 400 feet, at turnout basin 176¼ feet, and throughout the canal 80 feet. The depth of the water varies with the stage of the river. When the cross-dam on the crest of the falls is completed the minimum depth will be 6 feet.

The south bank of the canal and the greater portion of the north bank are protected by stone walls founded on the solid rock through which the canal is excavated. From the top of these walls, after leaving a berme of from 15 to 30 feet in width, earthen parapets with slopes of 2 on 1 rise to a height of 44 feet above the canal bottom and 1.3 feet above the highest known flood.

Near the head of the canal is a set of guard-gates used to shut out the water in case repairs are necessary. The locks are all placed at the lower or western end of the canal. The old set are now being remodeled by converting the three chambers into two of a size sufficient for passing all stern-wheel boats running during ordinary stages of the water, and all sizes of flat-boats and barges. The new locks form the outlet of a short branch leaving the canal a short distance above and entering the river a short distance below the old locks. The new locks are the pioneers of their size; they are two in number (combined), 80 feet in width, 372 feet in length between miter-posts with an available length of 335 feet; the lifts are 12 and 14 feet.

The side-walls, breast-walls, and bridge-piers are built of Cannelton limestone, laid in hydraulic cement in regular 2-foot courses. The masonry all rests upon the solid bed-rock which forms the floor of the lock-chambers.

The breast-walls and miter-sills are built in an arched form and abut in the side-walls. The arch and miter stones are 2 feet thick. They are laid in hydraulic cement, and in addition each stone is fastened to the solid-rock bed by 1¼-inch bolts 6 feet long. The timber cushions against which the gates close are of oak, and their top is flush with the stone-work. These timbers are bolted to the rock bed.

The dimensions of the gates are shown on the accompanying plans. The high guard or flood gates at the head of the new locks are built of oak and pine, and each leaf weighed when first launched 69.61 tons. These gates are much lighter in proportion than the lift-gates, having but a small water-pressure to stand. They were recently built by the United States at a cost of $6,227.59.

The upper lift-gates are built of oak and pine, while the lower and middle gates (lift-gates) are entirely of oak. The middle gates are the heaviest, each leaf weighing nearly 90 tons. The lift-gates were built by the canal company in accordance with plans prepared by Mr. T. R. Scowden; the contract price for the upper, middle, and lower set, exclusive of iron, was $8,700, $12,000, and $9,646.57 respectively. The quoin and miter posts of all the gates are built up of four pieces, firmly bolted and strapped together. A hollow cue extends through the posts of the high guard-gates, and by filling this cue with salt or some other preservative it is hoped that the posts, which usually are the first part of a gate to decay, can be made to last as long as the arms.

The guard-gates at the head of the canal were built in 1877 by the United States. They cost complete $4,690.79. They are of oak and pine, and the arms, or girders, are built beams, trussed with iron rods, and, as in the high guard gates, diagonal braces and planking were used. This plan has been adopted for the new gates about to be built for the old canal.

Each gate has a chilled-iron socket on the foot of the quoin-post, which rests and turns on a pivot bolted to the rock, and the top of the post is held by an iron collar. To relieve a portion of the weight on this collar and prevent sagging, a roller is placed under the lower arm near the miter-post, and in addition the lift-gates are suspended from masts.

The lock-chambers are filled and emptied through the lift-gates, there being in a set of gates 10 openings, each 30 feet by 36 feet. These openings are closed by cast-iron wickets turning on a vertical axis; they are moved by a lever through a vertical rod running to and projecting slightly above the top of the gate.

The gates are opened and closed by capstans, there being two for each set located on the adjacent side walls. The motion of the capstan is communicated by beveled gear to two horizontal shafts, being under the coping and parallel to the axis of the lock. At the end of these shafts are pinions working in large wheels which carry the drums on which wind the chains. Considering the upper drum, the chain is carried vertically downward through a well-hole under a friction-drum and out through the side walls over friction-rollers, 5 feet above the bottom of the lock; it is then attached to the gate of its own side, 5 feet above the foot of the miter-post. Considering the lower drum, the chain passes down and out similarly to the upper chain, and is then carried across and attached to the gate at the opposite side. As one chain winds the other unwinds, and thus turning the capstan in one direction opens the gate of its own side, while turning in the other direction closes the opposite gate. The openings in the side walls were placed 5 feet above the bottom of the lock to avoid as much as

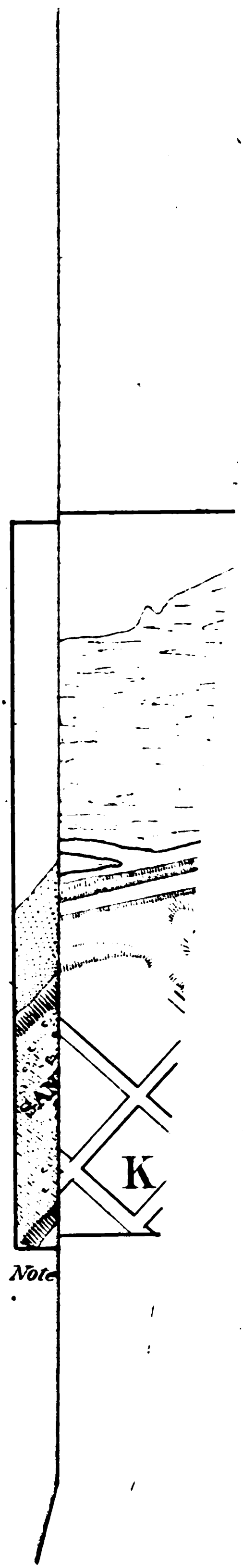


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Plate II.

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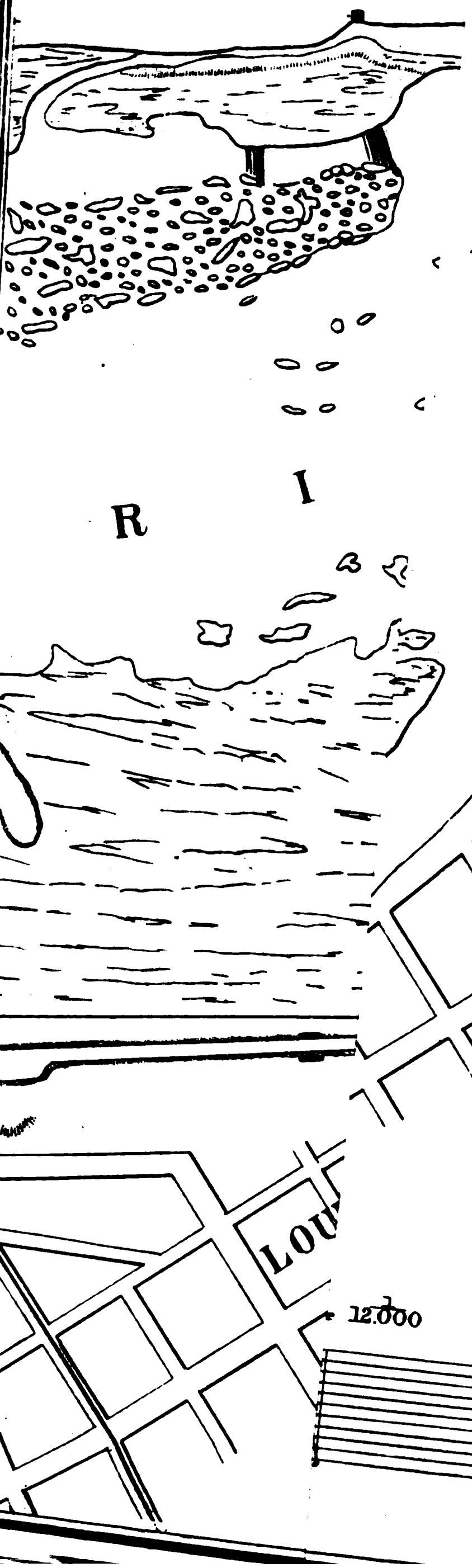

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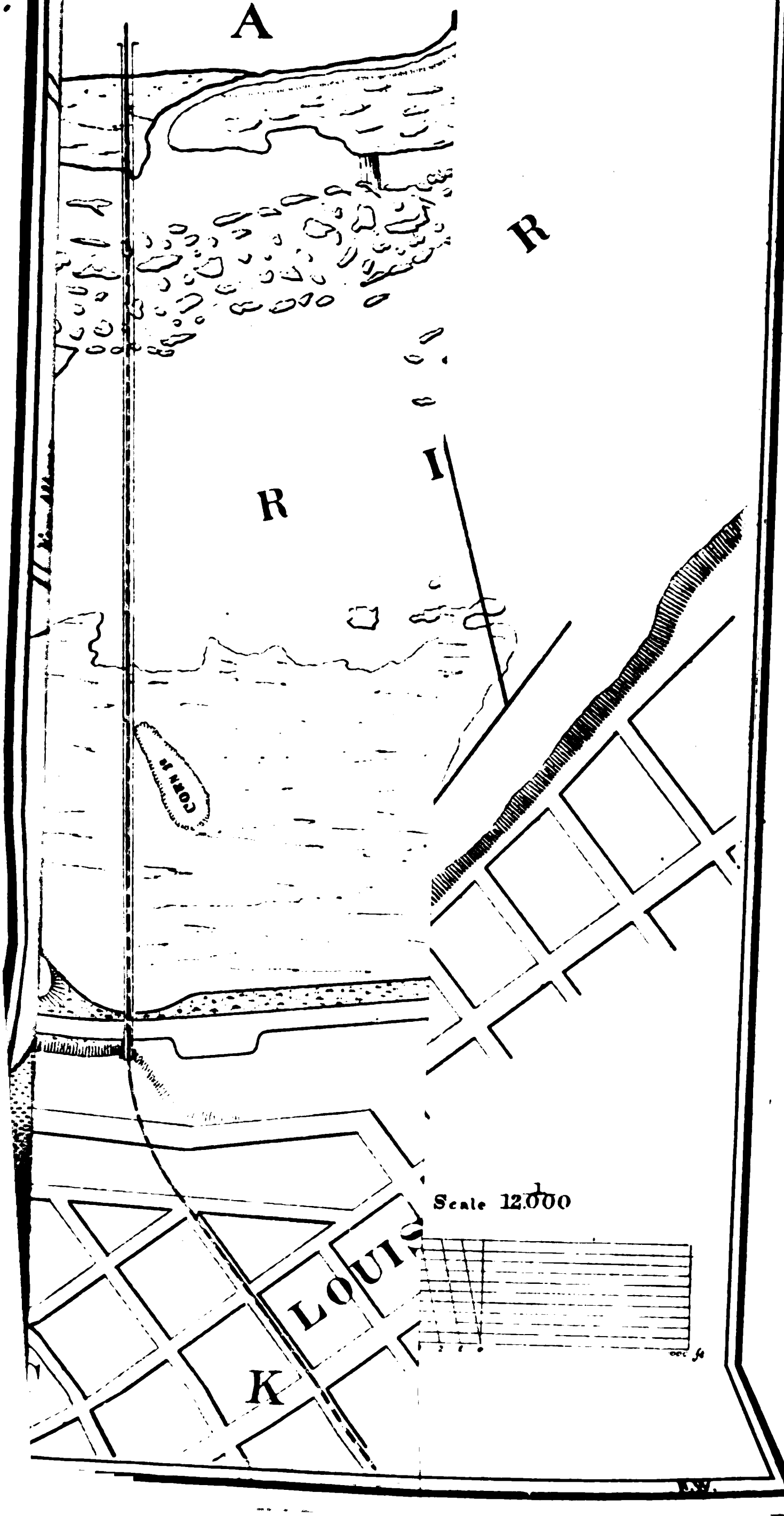

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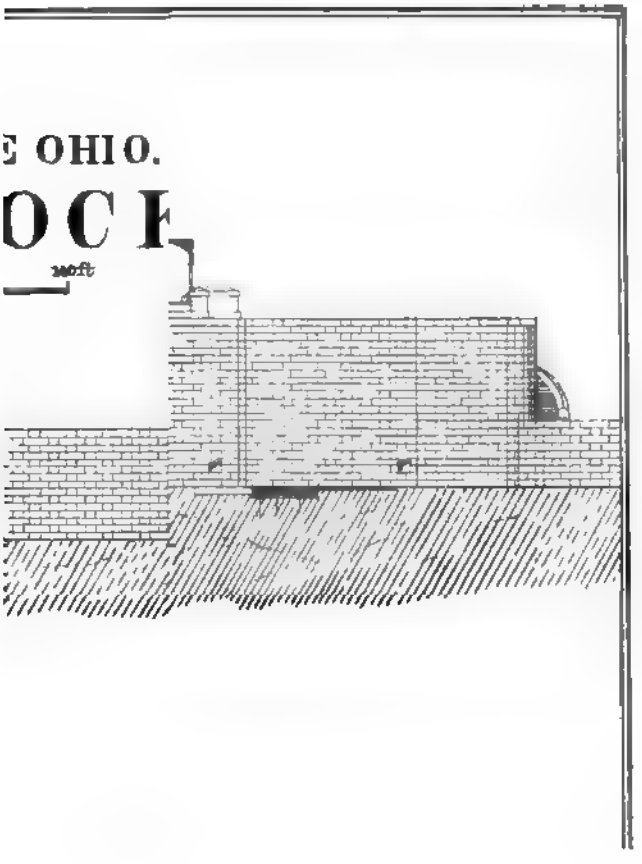

Plate V.

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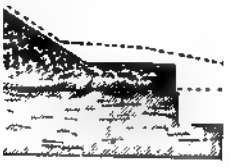

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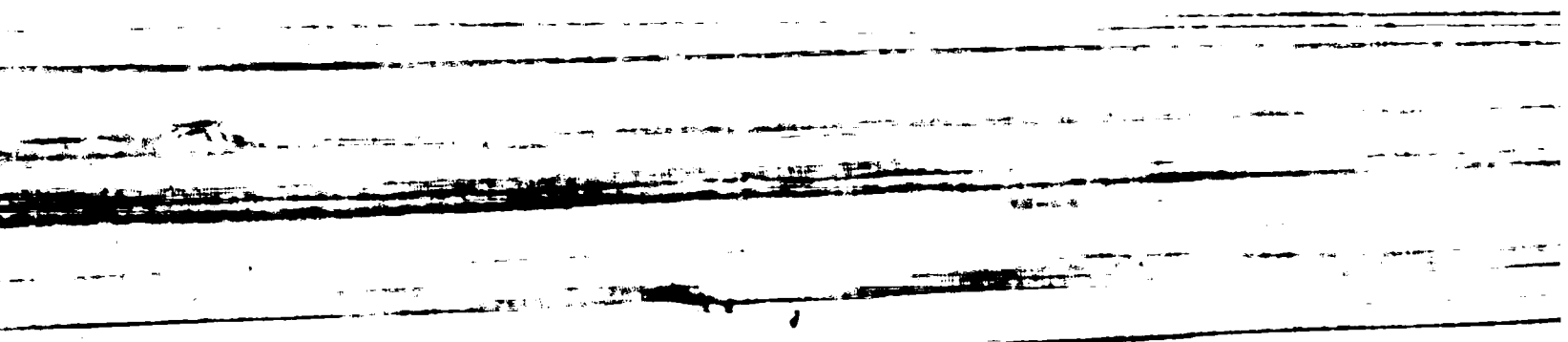

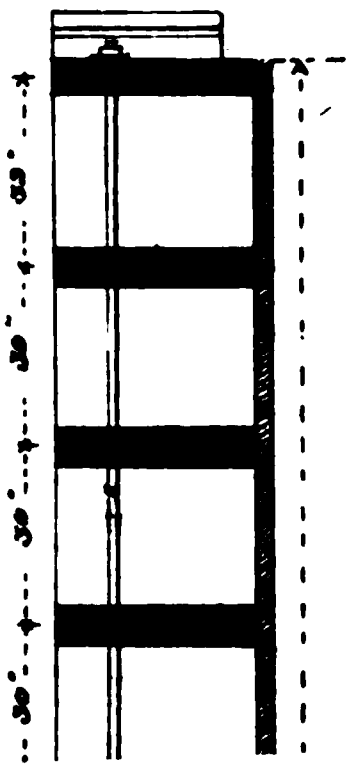

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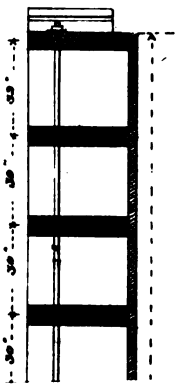

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ECTIONS

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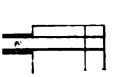
Plate VIII.



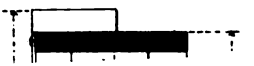
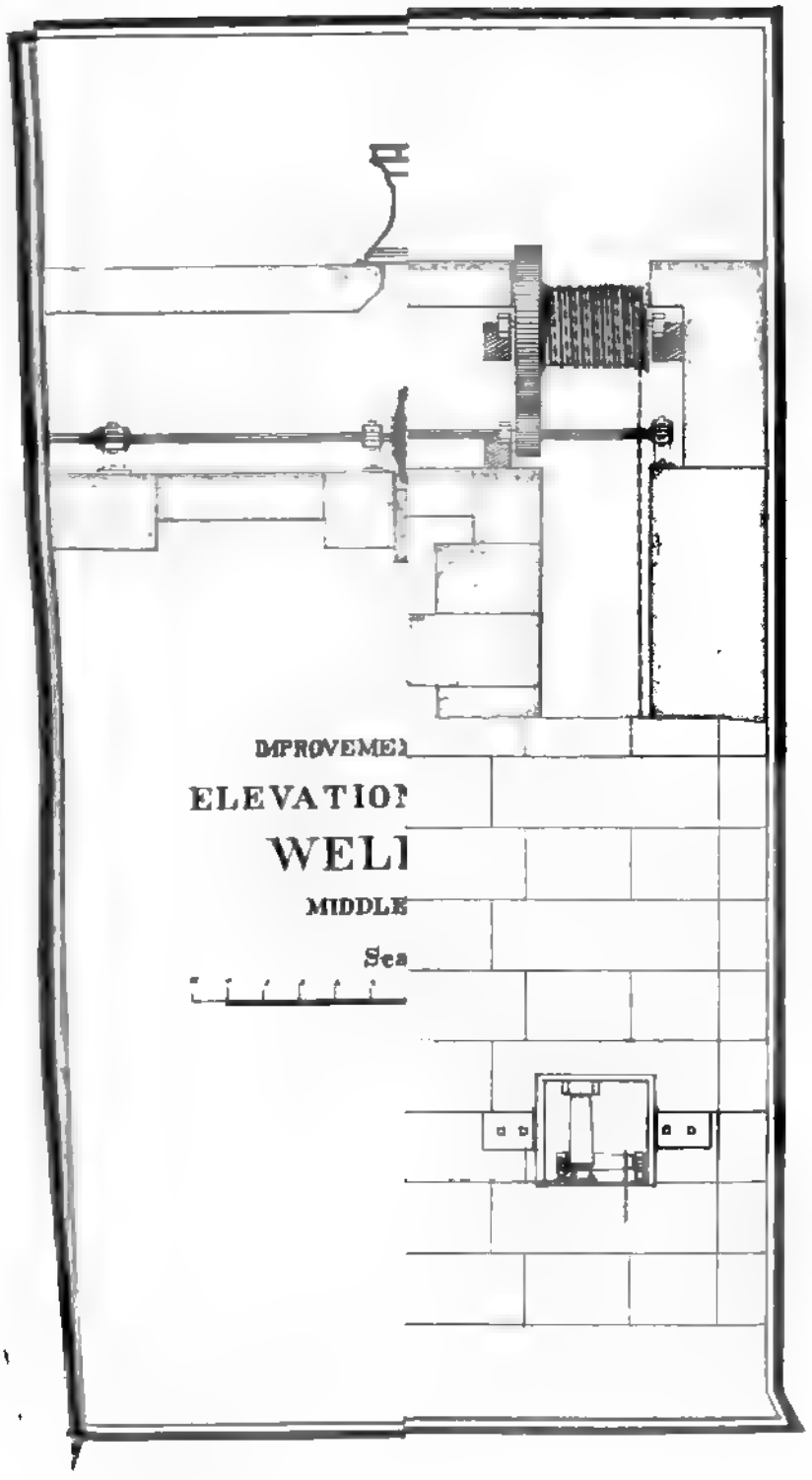


Plate IX



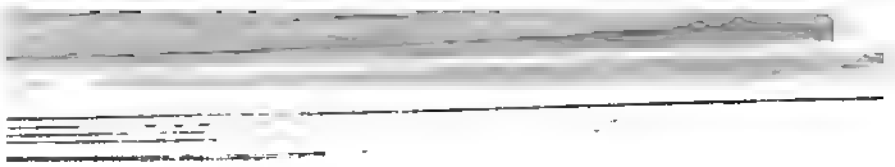
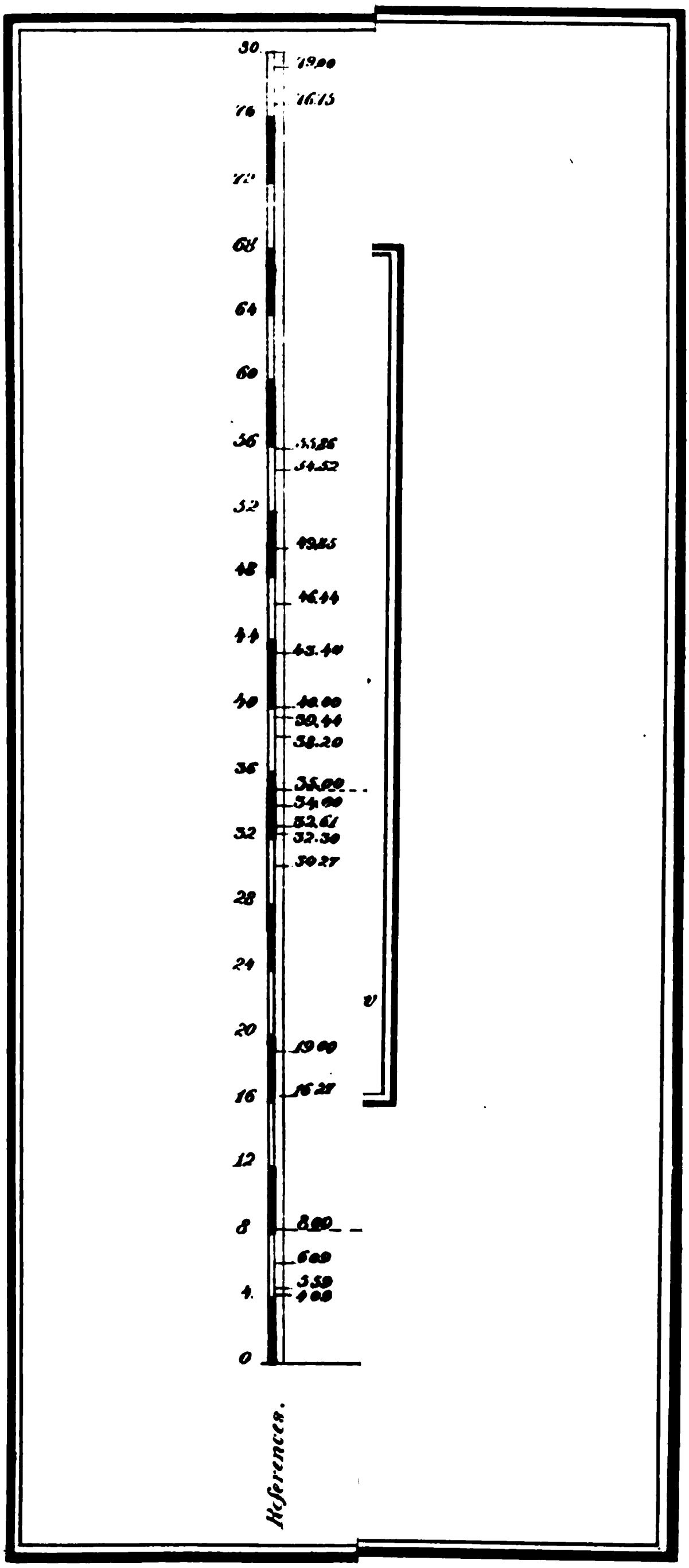


Plate X.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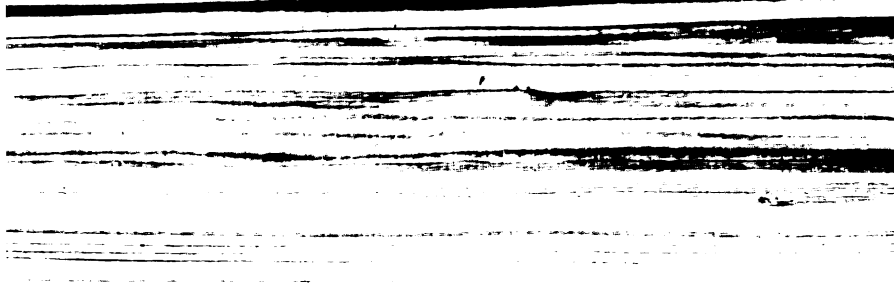


possible the deposit of sediment, and this height requires a certain amount of slack in the chains to prevent the catching of passing boats. For the middle lift-gates 1-inch chrome-steel chains are used, for the lower gates, 1-inch iron chains, and for other gates $\frac{7}{8}$-inch iron chains.

For what was considered good and sufficient reasons, when the gate machinery was first devised man-power was adopted, and it is still used on the capstans, but a more economical and as easily regulated power will soon be applied.

Rises in the river which submerge the lower locks are frequent, and occasionally both locks are entirely under water. At such times the sediment deposited is enormous. As an example, the amount of sediment left after the unusual rise of August, 1875, was as follows: In the new locks, 20,629 cubic yards, being 11 feet deep in the lower chamber; in the old locks, 9,000 cubic yards; and in the canal near its upper end, 24,000 cubic yards. This deposit, in a greater or less degree, is continually going on, and a steamboat, two dredges, and four dump-scows, all belonging to the canal, are constantly in use removing from the canal and locks every year nearly 100,000 cubic yards.

The time of lockage varies with the stage of water. When the river is high and but one chamber is used, a lockage occupies about half an hour, but at ordinary and low stages, when both chambers are used, one hour is necessary. With an extra force of men, the time of lockage for coal-tows through two chambers can be reduced to about 45 minutes. The opening or closing of a set of gates occupies about 7 minutes, and the filling or emptying chambers about 11 minutes.

The Louisville and Portland Canal, as regards power and time required for lockages, cannot be properly compared with other works, for at no canal in the world do we find at the same time such immense gates and so great an amount of sediment.

The experience of a few years on this work has suggested many changes and improvements, and when new and lighter lift-gates are substituted for those now in use, and when plans already perfected for facilitating their movement are put in operation, the trouble with sediment around gates will be done away with and the time of lockages will be reduced.

A dry-dock, corresponding in size to the old locks, is connected with the canal just above the new branch. This dock is cut out of the solid bed-rock.

A line of telegraph erected in 1876 connects the head and foot of the canal.

The canal offices, store-houses, and machine-shops are all located near the new locks.

The locks are illuminated by powerful reflecting lights, which make work by night as easy as by day.

The government assumed the management of the canal June 11, 1874, and immediately reduced tolls to less than one-fifth of former rates. It was predicted that with so great a reduction the canal could not be made self-sustaining, but, on the contrary, the receipts have not only been sufficient for all operating expenses, but have furnished a surplus fund, which has been used for making extensive repairs and improvements and putting all parts of the canal and accessories in perfect working order.

The plates accompanying this sketch show the condition of the canal before and subsequent to the enlargement, the three different classes of gates in use, details of the opening and closing gear, and the relative position of the different canal-gauges and scale of references. There is also given the references of the most important points in and above the canal.

On plate 5 are given sections of the locks, canal and retaining walls. Figure 1 is a representative section of the canal. It is taken about 100 feet south of the middle turnout basin. The dotted line shows the south bank and wall previous to enlargement.

Figure 2 represents the wall above the guard-gates. Figure 3 is a standard section of retaining wall from the guard-gate to the locks. Figure 4 is a section of the river wall in high-water channel throughout a half of draw in railroad-bridge. Figure 5 is a section of the guide-wall below the new locks. Figure 6 is a section of revetment wall at the foot of Ninth street, Louisville. Figure 7 gives an elevation of retaining wall, showing buttresses placed in wall. These buttresses were placed every 400 feet, and the courses of masonry ranged between two buttresses.

SUPERINTENDENCE, MANAGEMENT, AND REPAIR OF THE LOUISVILLE AND PORTLAND CANAL FOR THE YEAR ENDING DECEMBER 31, 1877.

WAR DEPARTMENT,
Washington City, January 16, 1878.

The Secretary of War has the honor to transmit to the United States Senate, for the information of the Committee on Commerce, a report of

Maj. G. Weitzel, Corps of Engineers, on the superintendence, management, and repair of the Louisville and Portland Canal, for the year ending December 31, 1877, with letter of the Chief of Engineers submitting the same.

The report is approved, and in accordance with the provisions of section 3 of the act of Congress of May 11, 1874 (18 Stat., p. 44), the rates of toll mentioned in the letter of the Chief of Engineers are declared and fixed as the charges to be collected for the current calendar year.

GEO. W. MCCRARY,
Secretary of War.

The PRESIDENT *of the United States Senate.*

LETTER OF THE CHIEF OF ENGINEERS.

OFFICE OF THE CHIEF OF ENGINEERS.
Washington, D. C., January 14, 1878.

SIR: To comply with the requirements of section 3 of the act of May 11, 1874, "providing for the payment of the bonds of the Louisville and Portland Canal Company" (Statutes at Large, vol. 18, page 43), I have the honor herewith to submit copies of the report of Maj. G. Weitzel, Corps of Engineers, on the superintendence, management, and repair of that canal for the calendar year ending December 31, 1877, and of the receipts and expenditures for the same period.

It will be seen that during the year the receipts have exceeded the expenditures in the sum of $27,519.58, and that the balance available on the 1st January, 1878, amounts to $54,519.68.

As in previous years, permanent improvements and repairs have been continued on different parts of the work, in order of their necessity, as rapidly as the excess of tolls over expenses of management would warrant; and it will be seen from this report that the policy adopted of continuing to place the canal and its appurtenances in better working condition has gradually and steadily given increased facilities to the business of the canal.

During the last half of the year 1874, 274,365 tons were passed through the canal, at an expense of 9.12 cents per ton for superintendence, management, and ordinary repairs; in the year 1875, 757,695 tons, at 6.14 cents per ton; in 1876, 871,446 tons, at 5.6 cents; and in 1877, 999,610 tons, at 4.97 cents per ton.

In view of the increase of the business and income of the canal during the year, and there being a balance sufficient to complete all the work remaining to be done on the canal, and still leave a sufficient surplus at the end of the year to meet any extra and unforeseen expenses that may arise, Major Weitzel recommends a further reduction of tolls, and that they be established at the following rates viz:

Steamboats and model barges, 8 cents per ton.
Square barges, flats, coal-boats, &c., 6 cents per ton.
All empty square barges and coal-boats, 5 cents per ton.
Small boats, $4.
Rafts of logs, &c., measurement and rates the same as for coal-boats.
Boats belonging to or chartered by the United States, free.
Towing, harbor rates.
Use of dredge, $2.50 per hour.
Use of steam-pump, $2.50 per hour.
Use of dry-dock, $15 first day, and $10 each subsequent day.

It being deemed prudent to have at all times an available surplus of at least $25,000, to meet any sudden and serious accidents that may

occur, in order to avoid interruption to commerce, a reduction of tolls greater than the above is not now advisable. There is little doubt, however, that in the next year a further reduction as great as this may be safely made.

Section 3 of the act of Congress above referred to contains the following provision:

> And, to ascertain what rates will pay current expenses after the present year (1874), the Secretary of War shall, on the first Monday in January of each year, ascertain from the expenses of the previous year what tolls will probably pay the expenses of the current year; and he shall fix and declare the rate of tolls thus ascertained to be charged for the current year; * * * and he shall, in his next annual report, set forth such receipts and expenditures, and the condition of said canal, with a view to such legislation as may be necessary for the superintendence and management thereof.

It is, therefore, respectfully recommended that the rates of toll above mentioned be adopted as those to be declared and fixed by your authority, in obedience to this law, as the charges to be collected for the current calendar year.

As the report of Major Weitzel contains matter of value relating to commerce and navigation, it is suggested that it be sent to Congress for the information of the Committees on Commerce of the Senate and House of Representatives.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brigadier-General and Chief of Engineers.

Hon. GEO. W. MCCRARY,
Secretary of War.

REPORT OF MAJOR G. WEITZEL, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Detroit Mich., January 4, 1878.

GENERAL: In accordance with your instructions and to enable the honorable Secretary of War to comply with the provisions of section 3 of the act of Congress, approved May 11, 1874, entitled

> An act providing for the payment of the bonds of the Louisville and Portland Canal Company—

I have the honor to submit the following report on the superintendence, management, and repair of the Louisville and Portland Canal for the calendar year ending December 31, 1877.

Capt. A. Mackenzie, Corps of Engineers, was my assistant in immediate charge of this work until November 22, 1877, when he was relieved by Capt. A. N. Lee, Corps of Engineers, who had been on duty on the work with him since September 8, 1877.

In the preparation of the report of Captain Lee, which is hereto annexed as part of this, he was materially assisted by Captain Mackenzie.

The tables, which are included in this report, give detailed statistics bearing on practical professional points.

We have continued to pursue the same policy which was adopted when the government first took charge of the work.

Permanent improvements and repairs were continued on different parts of the work, in the order of their necessity, as rapidly as we judged that the excess of tolls over the amount required for superintendence and management would warrant.

In pursuance of this policy and with your authority the following permanent improvements and repairs have been made during the past year, viz:

The repair of entire dredge apparatus, which had been previously begun, was completed. This apparatus consists of the tow-boat, two dredges, and four mud-scows, and is now in the most complete working order.

The guard-gates at the head of the canal and those at the head of the new locks were entirely rebuilt.

All the friction-drums in the well-holes of the new locks have been reset and greatly strengthened.

New winding-drums have been put in at the middle gates, and new gearing has been added, thus increasing the power of the capstan and strengthening all parts of the apparatus.

One-inch steel chains have been attached to the middle gates, in place of the seven-eighth-inch iron chains, which frequently broke.

The work of applying larger drums and stronger chains to the lower gates has been begun.

An office for the superintendent of the canal has been built.

A wood-boring apparatus has been added to the machinery of the shops.

A large portion of the slope adjacent to the locks has been graded and sodded.

A second fire-cistern, with a capacity of five hundred barrels, has been built near the toll-collector's house, and powerful fire-pumps and hose provided for it as well as the other fire-cistern near the machine-shop.

The miter-sills of the middle gates of the new locks were repaired.

The work of repairing the old locks and converting its three chambers into two was begun and prosecuted diligently until the rise in the river stopped the work. The lower sill has been thoroughly repaired; the greater portion of the rock excavation in the lower chamber has been completed, and the building of new gate recesses was begun.

New lights, furnished by the Light-House Establishment, have been placed in position, so that work by night is almost as easy as by day.

It will be seen from the annexed tables that the effect of our policy in placing the canal and appurtenances in better working condition has gradually and steadly improved the business of the canal.

During the last six and two-thirds months of 1874, 274,365 tons were passed through at an expense of 9.12 cents per ton for superintendence, management, and ordinary repairs. In 1875, 757,695¾ tons, at 6.14 cents per ton. In 1876, 871,446½, at 5.6 cents per ton, and in 1877, 999,610$\frac{4}{10}$ tons, at 4.97 cents per ton.

The expense during the last year in passing the three greatest articles which go through in bulk, was as follows, viz: coal, $\frac{1}{6}$ cent per bushel; salt, 1$\frac{1}{4}$ cent per barrel; and iron-ore, 8$\frac{3}{5}$ cents per ton.

According to the books in my office, the receipts during the last year amounted to $88,462.10, and the total expenditures, $60,942.42. This leaves a surplus for the year of $27,519.68. There was on hand at the beginning of the year $26,955.60; so that we had $54,475.28 on hand on the first of this month.

In Captain Lee's report, the expense for repairing friction-drums, winding-gear, steel chains, &c., is incorrectly charged to the running expenses of the canal. They are all permanent repairs, and their cost amounted to about $3,500. The amount expended for permanent improvements and repairs during the year was, therefore, about $15,000. The running expenses of the canal, including the ordinary repairs, was, therefore, about $46,000.

It will be further observed by examining the table of receipts, that

the business and income of the canal was considerably increased over the year preceding, in spite of the fact that during a part of August, and the whole of September and October, navigation was almost entirely suspended by low-water, and in spite of the fact that the receipts were diminished $3,270.72 by reducing the rate on empty coal-barges, on their return-trip.

For this reason, and as we now have on hand the very handsome surplus of $54,475.28, which will not only complete all the work still to be done and that which is already authorized but still leave us a good surplus at the end of this year, I take great pleasure in recommending a reduction of tolls, and that they be fixed at the following rates, viz:

Steamboats and model barges, 8 cents per ton.
Square barges, flats, coal-boats, &c., 6 cents per ton.
All empty square barges and coal-boats, 5 cents per ton.
Small boats, $4.
Rafts of logs, &c., measurement and rates, the same as for coal-boats.
Boats belonging to or chartered by the United States, free.
Towing, harbor rates.
Use of dredge, $2.50 per hour.
Use of steam-pump, $2.50 per hour.
Use of dry-dock, $15 first day, and $10 each subsequent day.

The rates heretofore charged by the government were a little less than one-fifth of those charged by the former management. The new rates will be a little less than one-sixth of those.

As there is always more or less liability to serious accidents on canal-locks, and especially on such large ones as those of this canal, I think it wise and prudent to have at all times an available surplus of at least $25,000; hence I do not recommend now a greater reduction. I have not the least doubt that next year a further reduction, and one as large as now recommended, may be safely made.

The total receipts on this canal from June 11, 1874, to December 31, 1877, during which time the government has had charge of it, amount to $259,795.51; the total expenditures, $205,320.23, leaving the surplus of $54,475.28. The expenditures include about $45,000 for permanent repairs.

By the use of the canal force and the machinery in the canal shops, a saving of $15,000 below fair contract prices has been effected in the work already done.

In conclusion I desire to commend Captains Mackenzie and Lee and their assistants for the faithful and economical manner in which they have conducted this work.

Annexed hereto is the financial statement for the year.

Very respectfully, your obedient servant,

G. WEITZEL,
Major of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

Financial statement for calendar year ending December 31, 1877.

Deposits.		Expenditures.	
Month.	Amount.	Month.	Amount.
1877.		1877.	
January	$820 56	January	$3,431 11
February	9,269 36	February	4,056 [illegible]
March	3,867 36	March	5,092 [illegible]
April	11,256 46	April	5,244 [illegible]
May	11,678 01	May	4,675 [illegible]
June	10,390 34	June	6,302 [illegible]
July	9,631 25	July	60 16
August	3,798 59	August	8,716 [illegible]
September	1,957 20	September	1,220 [illegible]
October	1,930 00	October	9,994 [illegible]
November	9,498 95	November	6,167 [illegible]
December	14,364 02	December	5,352 64
Total	88,462 10	Total	60,987 42

Cash on hand December 31, 1876	$26,955 00
Surplus for 1877	27,519 06
Cash on hand December 31, 1877	54,475 28

REPORT OF CAPTAIN A. N. LEE, CORPS OF ENGINEERS.

LOUISVILLE AND PORTLAND CANAL OFFICE,
Louisville, Ky., December 31, 1877.

SIR: In accordance with your instructions, I have the honor to submit the following report upon the superintendence, management, and repair of the Louisville and Portland Canal for the calendar year ending December 31, 1877.

Detailed reports have been made semi-annually since the government assumed control of the canal, and to avoid a repetition it will be sufficient to say that the principle adopted of placing all parts of the canal in perfect working order as fast as economical expenditure of receipts would permit has been carried out, and the close of the year finds the canal and accessories in a better condition than ever before.

WORK ACCOMPLISHED DURING THE YEAR.

The rebuilding of dredge No. 2 and dump-scow No. 4 was completed in January, and new dippers were subsequently put on both dredges. This closed the extensive repairs of dredging apparatus, leaving tow-boats, dredges, scows, &c., in very good condition, with at least double the capacity they had before repairs were made.

Two new sets of gates have been built, one for the head of the new locks and one for the head of the canal.

The friction-drums in all the well-holes of the new locks have been reset and greatly strengthened.

New winding-drums have been put in at the middle gates of the new locks, and gearing has been added, increasing somewhat the power of the capstans and strengthening all parts of the apparatus.

One-inch steel chains have been attached to the middle gates, replacing the $\frac{7}{8}$-inch iron chains which formerly caused great annoyance by frequently breaking.

The new and enlarged drums and heavy chains have proved such a success that arrangements have already been made for making similar changes at the lower gates.

An office for the superintendent of the canal has been completed.

A boring apparatus has been added to the machinery of the shops.

A large portion of the slope in the vicinity of the locks has been graded and sodded.

A second fire-cistern, holding 500 barrels, has been built near the toll-collector's house, and powerful fire-pumps with requisite hose have been provided for Nos. 1 and 2.

On the 18th of September, the water being low and business almost suspended, the canal was closed for repairing the middle miter-sill of the new locks. All broken and injured stones were replaced by hard limestone set in Portland cement; new bolts were driven, and all parts of the sill and wooden cushion made as firm as possible. This work occupied about sixteen days, and the canal was reopened October 5.

The repairs of the middle miter-sill were made as thorough as possible; but the work can only be considered temporary. When time will permit, the whole sill must be rebuilt.

While the water was out the miter-sill and roller-ways of the guard-gates at the head of the canal were thoronghly repaired.

In September authority was obtained for making extensive repairs on the old locks, converting the three lifts into two, and giving chambers that will not only pass all the stern-wheel boats running during low-water, but will also afford great relief when coal-tows are passing through the canal. Already the lower miter-sill and roller-ways have been thoroughly repaired, the greater portion of the rock excavation in the lower chamber has been made, and the building of new gate recesses has been commenced.

During the year new lights, furnished by the Light-House Department, have been put up at the new locks. Work by night is now about as easy as work by day.

Most all of the work above referred to, in addition to numerous minor improvements, ordinary repairs, and regular duties, has been carried on under the immediate direction of the superintendent, and as far as possible the work has been done by the regular employed mechanics and laborers.

The work done by tow-boat and dredges, and by the lock-hands in passing boats, is given in tables annexed.

NUMBER AND SALARY OF EMPLOYÉS.

During the past year extra mechanics and laborers have been employed upon works of improvement, but the regular canal force has remained as given in last annual report, excepting that the position of "foreman of dredges" has been done away with.

The regular pay-roll of employés now amounts to $38,115. Since the government assumed control of the canal, the pay-roll has been reduced $1,845. It is almost certain that further reductions will be made during the coming year.

RATES OF TOLL.

The rates of toll charged during the past year have been the same as charged during the year 1876, excepting that the recommendation to reduce tolls on empty barges on a return trip, from 8 to 5 cents, was approved February 26, 1877. This change has reduced the receipts during the year $3,270.72.

RECEIPTS AND EXPENDITURES.

The receipts for the year have amounted to $88,737.28, being $27,351.33 in excess of the total expenditures, and $39,240.67 in excess of the operating expenses.

There has been expended during the year $61,385.95; of this amount $11,889.34 was applied to extensive repairs and improvements of a permanent nature, leaving $49,496.61 as the expense of operating the canal. These operating expenses include large amounts paid for repairing friction-drums, winding-gear, &c., and are for that reason in excess of similar expenses in 1876.

The operating expenses of this canal are very large in consequence of the heavy deposits of sediment and cost of removing, as well as the size and weight of the gates and the force required to move them. No comparisons can be made with the expense of operating other canals, for at no other point is the same combination of difficulties met with. When new gates are built, sink-basins provided, and other than man-power employed, expenses can be greatly reduced.

The total receipts since the government assumed charge of the canal in June, 1874, have amounted to $260,070.69, and the total disbursements, including $40,589.92 expended on permanent work, have amounted to $205,763.76, showing a saving with reduced tolls of $54,306.93.

Authority has been granted from time to time for doing work amounting, at fair contract prices, to $43,650. This work has cost but $28,292.22. This saving may be attributed to the doing of work gradually under the direction of the superintendent of the canal and to the use of machinery in the canal shops.

WORK PROJECTED FOR NEXT YEAR.

During the coming year the works of improvement given in the report for the year 1876 will be carried out as fast as authority is obtained and an economical system of working will permit.

Cottages for the lock-hands and a coal-elevator will be erected, steam-power will be tried on the gates, and the repairs of the old locks will be completed if the stage of the river will permit.

Former reports have referred to many extensive improvements, such as building a

new wall on the north side of the canal, enlarging the dry-dock, building large basins above and below the new locks to lessen obstruction of the canal during coal-runs, rebuilding miter-sills, and providing sink-basins to remove deposit from front of gates.

On account of expense it has rather been assumed that much, if not all, of this work would, if done, be paid for by appropriation and not from the tolls collected.

CONCLUSION AND RECOMMENDATIONS.

While the past year, owing to more continued low water, has not been perhaps quite as favorable for navigation as the year 1876, yet the receipts, owing to the heavy coal-runs of November and December, have been larger, and it is evident that the canal can be made self-sustaining with even a lower rate of toll than is now charged.

Assuming that appropriations will be made for the most extensive improvements and enlargements, and considering that the heaviest outlays for repairs of the working parts of the canal are either paid or provided for by the present balance, I think a gradual reduction in the rate of toll should now be commenced, but to insure a surplus fund the reduction must be gradual.

I am of the opinion that if the tolls are reduced one-fifth the receipts for the year 1878, together with the balance now on hand, will not only be sufficient to pay expenses of "superintendence, management, and repair," complete the work on the old locks, build cottages and coal elevator, and if necessary new middle gates, but will also give a balance at the end of the year 1878 of at least $25,000.

I would recommend that the present system of management be continued.

I would recommend the following rate of tolls and charges for the year 1878:

Toll on—

Steamboats and model barges, 8 cents per ton.

Square barges, flats, coal-boats, &c., 6 cents per ton.

All empty square barges and coal-boats, 5 cents per ton.

Small boats, $4.

Rafts of logs, &c., measurements and rates the same as for coal-boats.

Boats belonging to or chartered by the United States, free.

Charges for—

Towing, harbor rates.

Use of dredge, $2.50 per hour.

Use of steam-pump, $2.50 per hour.

Use of dry-dock, $15 first day, and $10 each subsequent day.

I would respectfully renew the recommendations made in the report for the calendar year 1876, and especially that referring to rules and regulations.

In conclusion, I would bear witness to the faithful, just, and efficient manner in which the superintendent and his assistants have performed their duties, often rendered very difficult by the conflicting interests and opinions of steamboat-men, some of whom have, during the past year as well as during previous years, ever been ready to find fault and condemn without reason, when the decision or order of the superintendent was not in accordance with their individual opinions and for their special benefit.

Very respectfully, your obedient servant,

A. N. LEE,
Captain of Engineers.

Maj. G. WEITZEL,
Corps of Engineers, U. S. A.

[illegible] Portland Canal, number of lockages, and amount dredged, for the year ending December 31, 1877.

Month.	Number and under-tonnage of steamboats, barges, and small boats, &c.													Number of lockages.		Greatest number of lockages in one day.						Number of days closed by ice, high water, repairs, &c.	Number of miles run by tow-boat.	Number of cubic yards of sediment removed.
	Passenger-boats.		Tow-boats.		Model barges.		Square barges.		Empty barges on return trip.		Small boats.	Total.												
	Number.	Under-tonnage.	Number.	Under-tonnage.	Number.	Under-tonnage.	Number.	Measured capacity.	Number.	Measured capacity.		Number.	Under-tonnage.	Day.	Night.	Number of lockages.	Number of chambers.	No. of boats passed.	Number of tons.	Time occupied.				
1877.																				h.	m.			
January	3	858	6	1,361	5	1,075	30	9,323	....	.....	5	49	12,617	5	12	7	2	19	5,295	10	10	28	19	1,216
February	61	27,186	38	5,518	49	11,315	201	59,630	....	.....	13	362	103,649	84	82	15	1	41	14,431	18	30	.....	177	10,184
March	40	17,286	11	1,491	26	6,480	53	12,333	....	.....	12	142	37,590	37	35	9	2	29	7,560	12	30	13	165	11,248
April	56	25,884.8	38	6,192	60	15,101	284	82,911	71	20,120	16	525	150,208.8	116	78	21	2	71	18,582	21	15	3	114	8,094
May	74	32,682	39	6,837	77	19,969	150	39,902	86	20,569	23	449	119,959	87	85	13	2	40	10,134	13	50	.....	236	11,020
June	79	34,347	44	5,720	82	19,931	180	47,248	32	7,505	11	428	114,751	98	81	13	2	46	13,477	18	00	.....	142	10,146
July	79	33,984	38	5,887	76	20,434	106	27,785	102	28,041	13	414	116,131	99	76	12	2	34	10,510	12	05	.....	230	11,704
August	83	25,676	38	2,585	29	5,256	34	3,822	1	273	19	204	37,612	59	63	8	2	15	3,203	8	35	.....	47	4,598
September	50	10,811	4	343	9	1,693	15	1,766	16	4,042	2	96	18,655	34	24	6	2	10	1,774	8	50	12	137	2,166
October	64	14,243	25	1,510	9	1,629	37	3,441	....	.....	9	144	20,821	61	29	7	2	14	1,305	9	15	4	112	3,952
November	95	31,006	45	5,193	72	16,737	204	38,538	58	14,931	44	518	96,405	131	80	16	2	51	13,522	18	35	.....	172	1,444
December	86	34,343	48	8,087	69	18,073	279	97,166	60	13,543	8	550	171,212	126	82	14	2	24	11,447	12	05	.....	100	3,306
Total	770	288,306.8	374	50,724	563	127,691	1,573	423,865	426	109,024	175	3,881	999,610.8	937	727	....	....	....	.....	.....		60	1,651	79,078

Detailed statement of expenditures for superintendence, management, ... rille and Portland Canal for the year ending December 31, ...

Date.	Lockage department.			Dredge department.			Improvements.	Grand total.
	Labor.	Purchase and repairs.	Total.	Labor.	Purchase and repairs.	Total.		
1877.								
January	$2,330 00	$82 49	$2,412 49	$905 00	$74 18	$979 18	$394 03	$3,785 70
February	2,446 67	263 60	2,710 27	1,044 50	329 75	1,373 31	177 96	4,261 54
March	2,380 00	645 78	3,025 78	015 00	366 91	1,281 91	719 36	5,027 05
April	2,458 50	1,472 78	3,931 28	028 50	240 62	1,169 12	878 91	5,979 31
May	2,418 33	191 63	2,609 96	915 00	296 98	1,211 98	982 87	4,804 81
June	2,424 33	862 80	3,287 13	927 33	260 15	1,187 48	1,011 89	5,486 50
July	2,384 83	264 04	2,648 87	925 58	194 80	1,120 38	1,172 43	4,941 68
August	2,330 00	230 01	2,560 01	915 00	261 85	1,176 85	1,368 13	5,104 99
September	2,205 00	1,083 71	3,288 71	900 00	235 82	1,135 82	1,417 42	5,841 95
October	2,286 00	1,101 71	3,387 71	852 00	170 16	1,022 16	2,178 12	6,587 99
November	2,247 52	814 05	3,061 57	821 34	203 98	1,025 32	1,084 66	5,171 55
December	2,697 50	147 97	2,845 56	820 00	223 76	1,043 76	503 56	4,392 88
Total	28,608 77	7,160 57	35,769 34	10,869 31	2,857 96	13,727 27	11,889 34	61,385

Statement of amount of coal, salt, and iron ore passed through the Louisville and Port... Canal for the year ending December 31, 1877.

Designation.	Number of tons charged for.	Number of bushels, barrels, or tons carried.	Amount of toll collected.	Cost of loc... one bush... rel, or t...
Coal	274,223	12,975,200 bushels	$22,346 46	.166 c.
Salt	26,120	211,200 barrels	2,668 56	1.07 c.
Iron ore	21,873	27,893 tons	2,256 40	8.61 c.

Comparative statement of receipts, boats passed, work done, and expenses, Louisville and Portland Canal, for the year ending December 31, 1877.

Year.	Monthly receipts.												Source.				
	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December	Tolls.	Dry-dock.	Towing.	Rents.	Total.
1874						$2,744 85	$1,460 65	$3,227 65	$1,249 05	$1,488 55	$1,704 08	$8,520 70	$19,606 25	$464 28	$45 00	$280 00	$20,395 53
1875	$3,015 25	$2,092 40	$1,525 76	$10,277 44	$12,935 48	7,447 07	2,864 96	3,406 81	3,715 86	3,289 32	8,225 00	11,380 26	68,664 75	599 21	350 00	561 65	70,175 61
1876	2,953 47	1,342 81	7,660 22	10,204 40	14,927 99	8,005 42	6,611 78	5,388 52	4,765 66	6,920 33	9,367 93	2,613 74	79,854 31	220 96	275 00	412 00	80,762 27
1877	1,100 24	9,311 30	3,598 34	12,509 91	10,501 41	10,260 89	9,822 85	3,891 11	1,673 08	2,058 48	9,410 19	14,599 48	87,907 78	195 00	223 50	411 00	88,737 28
Total	7,068 96	12,746 51	12,784 32	32,991 75	38,364 88	28,458 23	20,760 24	15,914 09	11,403 75	13,756 68	28,707 20	37,114 18	256,033 09	1,479 45	816 00	1,664 65	260,070 69

Year.	Steamboats.		Tow-boats.		Model barges.		Square barges.		Small boats.	Total boats and tonnage.		Number of cubic yards dredged.	Number of miles run by tow-boat.	Number of days locks closed.	Number of lockages.	Cost per ton, including total expenses of management.
	Number.	Under-tonnage.	Number.	Under-tonnage.	Number.	Under-tonnage.	Number.	Measured capacity.	Number.	Number.	Tonnage.					
1874	343	101,016	92	14,440			690	158,909	39	1,164	274,365					$9 12
1875	647	234,248	281	44,420	593	146,517½	1,270	333,510¼	90	2,881	757,695¾	90,488	1,863.5	93	1,401	6 14
1876	824	295,262	267	45,583	571	141,858½	1,474	388,743	128	3,264	871,446⅓	94,988	2,173	59	1,604	5 06
1877	770	288,306.8	374	50,724	563	127,693	1,999	532,889	175	3,881	999,610.8	79,078	1,651	60	1,664	4 97
Total	2,584	918,832.8	1,014	155,167	1,727	416,069	5,433	1,414,051¼	432	11,190	2,904,117½⅚	264,554	5,687.5	212	4,669	

Comparative statement of receipts, boats passed, work done, and expenses, Louisville and Portland Canal, &c.—Continued.

Year.	Expenses lockage department.								Expenses dredge department.								Total superintendence, management, and repair.	Permanent improvements.	Grand total.
	Labor.		Repairs.	Lights.	Forage.	General purchases.	Office expenses.	Total.	Labor.		Repairs.	Fuel.	Lubricating oil.	General purchases.	Total.				
	Regular.	Extra.							Regular.	Night-work.									
1874	$15,099 78	.....	$420 43	$44 27	$275 02	$85 80	$35 45	$15,960 75	$6,830 00	.....	$459 96	$1,599 00	$106 95	$69 50	$9,065 41		$25,026 16	$115 95	$25,142 11
1875	27,720 00	$545 57	700 63	108 85	337 07	67 21	39 08	29,518 41	12,240 00	$633 19	884 22	3,053 25	186 80	69 51	17,066 97		46,585 38	3,174 11	49,759 49
1876	26,870 00	299 86	1,141 74	123 12	294 38	143 25	173 43	29,045 78	11,760 00	265 42	797 87	2,070 00	104 87	19 75	15,019 91		44,065 69	25,410 52	69,476 21
1877	27,465 00	1,143 77	5,861 34	162 12	305 32	692 41	139 38	35,769 34	10,650 00	219 31	378 86	2,101 33	199 03	178 74	13,727 27		49,496 61	11,889 34	61,385 95
Total	97,154 78	1,989 20	8,124 14	438 36	1,211 79	988 67	387 34	110,294 28	41,480 00	1,117 92	2,520 91	8,825 58	597 65	337 50	54,879 56		165,173 84	40,589 92	205,763 76

Statement of expenses with cost of dredging, lockage, &c., Louisville and Portland Canal, for year ending December 31, 1877.

Month.	Lockage department.				Dredging department.						Lockage and dredging departments combined.						
	Monthly expenditures.	Cost per lockage.	Cost per boat.	Cost per ton under tonnage.	Monthly expenditures.	Cost per cubic yard.	Deduction for tow-boat and dredge earnings.		True cost of dredging.		Monthly expenditures.	Cost per lockage.	Cost per boat.	Cost per ton under tonnage.	Cost per bushel of coal.	Cost per ton of iron-ore.	Cost per barrel of salt.
							Lost time.	Tow-boat and dredge earnings.	Monthly.	Per cubic yard.							
				Cts.		*Cts.*				*Cts.*				*Cts.*	*Cts.*	*Cts.*	*Cts.*
January	$2,412 49	$141 32	$49 23	19.1	$979 18	80.5	$868 63	.....	$110 55	09	$3,391 67	$199 51	$69 22	26.9	0.173	.....	0.64
February	2,710 27	16 32	7 48	02.6	1,373 31	13,4	294 28	$2 00	1,077 03	10.6	4,083 58	24 60	11 28	04	0.161	9.60	1.16
March	3,025 78	42 02	21 02	08.1	1,281 91	11.4	372 15	.....	909 76	08.09	4,307 69	59 82	30 34	11.4	0.169	5.90	.....
April	3,931 28	20 26	7 49	02.6	1,169 12	14.4	506 61	42 00	620 51	07.6	5,100 40	26 30	9 71	03.4	0.179	7.40	1.16
May	2,609 96	15 17	5 81	02	1,211 98	10.9	234 57	135 00	842 41	07.6	3,821 94	22 22	8 51	03.2	0.151	8.64	1.14
June	3,287 13	18 36	7 68	02.9	1,187 48	11.7	435 41	.....	752 07	07.4	4,474 61	25 00	10 45	03.9	0.166	8.13	1.17
July	2,648 87	15 13	6 40	02.3	1,120 38	09.5	252 98	.....	867 40	07.4	3,769 25	21 54	9 10	03.2	0.174	8.66	1.12
August	2,560 01	20 98	12 55	06.8	1,176 85	25.6	303 70	5 00	868 15	18.9	3,736 86	30 63	18 31	09.9	.....	.....	1.11
September	3,288 71	56 70	38 42	17.6	1,135 82	52.4	719 34	20 00	396 48	18.3	4,424 53	76 29	46 09	23.7	.....	.....	.....
October	3,387 71	37 64	23 53	11.4	1,022 16	25.8	493 59	.....	528 57	13.4	4,409 87	49 00	30 62	21.2	.....	.....	.....
November	3,061 57	14 51	5 91	03.1	1,025 32	71	615 18	17 00	393 14	27.2	4,086 89	19 37	7 89	04.2	0.162	.....	1.09
December	2,845 56	13 68	5 17	01.6	1,043 76	31.5	740 74	2 50	300 52	09.1	3,889 32	16 29	6 16	02	0.176	11.91	.....
Total	35,769 34	21 49.6	9 21.0	03.5	13,727 27	17.3	5,837 18	223 50	7,666 59	09.7	49,496 61	29 74	12 75	04.9	0.171+	8.09	1.26

Statement of receipts of Louisville and Portland Canal for the year ending December 31, 1877.

Number.	Designation.	Number of tons.	Price per ton.	Amount of tolls collected.
770	Steamboats	288,306.8	10 cents.	28,830 68
374	Tow-boats	50,724	10 cents.	5,072 40
563	Model barges	127,693	10 cents.	12,769 30
1,573	Square barges	423,865	8 cents.	33,909 20
426	Empty barges	109,024	5 cents.	5,451 20
175	Small boats		$5 each	875 00

Collections from tolls	$87,907 78
Collections from dry-dock	195 00
Collections from towage	146 00
Collections from dredging	77 50
Collections from rents	411 00
Total collections for year 1877	88,737 28

APPENDIX U.

ANNUAL REPORT UPON THE WORKS IN CHARGE OF MAJOR WILLIAM E. MERRILL, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1878, BY LIEUTENANT F. A. MAHAN, CORPS OF ENGINEERS, TEMPORARILY IN CHARGE.

UNITED STATES ENGINEER OFFICE,
Pittsburgh, Pa., August 24, 1878.

GENERAL: I have the honor to transmit herewith the annual reports of the Ohio, Monongahela, and Little Kanawha rivers for the year ending June 30, 1878.

Very respectfully, your obedient servant,

F. A. MAHAN,
First Lieutenant Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers.

U 1.

IMPROVING OHIO RIVER.

Owing to the fact that no appropriation was made in 1877 for carrying on work on the Ohio, but little could be done. The dike at White's Ripple, 11 miles below Pittsburgh, was extended. Rocks were removed at various points along the upper river. The snag-boat E. A. Woodruff and the dredges Ohio and Oswego were at work during the low-water season.

DIKE AT WHITE'S RIPPLE
(11 miles below Pittsburgh).

During the season of 1876, 985 feet of this work was finished. In July, 1877, operations were resumed and 1,808 feet more was completed. A dam was also built between the foot of Neville Island and the tow-head from which the dike starts. During the present summer the dike and a cross-dam from the dike to the left bank of the river will probably be completed. The details of this work will be found in the following report of Mr. I. V. Hoag, jr.:

White's Ripple and The Trap, 11 and 12 miles below Pittsburgh, was once one of the most troublesome points on the Ohio River.

At the foot of Neville Island, 10½ miles below Pittsburgh, there is a large gravel bar or tow-head, half a mile in length and varying from 5 to 12 feet in height above low-water. It is separated from the island by a narrow chute, through which the water flows at a 3-foot stage. From this bar for a distance of three-fourths of a mile the river is known as White's Ripple, the foot of the shoal being known as The Trap.

In July, 1838, a riprap dike for the improvement of this place was begun. Captain Sanders, in his report for 1838, says: "The project consisted of a continuous dike of about 1 mile in length. The head of the dike was on the right shore of Neville Island,

a short distance from the foot of the island. Its direction was nearly parallel to the channel of the river. It passed over two bars which were dry at low-water and terminated below The Trap by inclining toward the left shore."

The dike was completed from the island to the first bar or tow-head, and from this bar it was partly built for almost its entire length. For want of funds it was left in this unfinished state in 1840. In 1843 work was resumed and nearly completed by the following year.

In a report of December 3, 1844, the engineer in charge says:

"When a shoal is very long, embracing several ripples, the long longitudinal dike required for concentrating the water over the ripple may need the support which will be given by a transverse dam which will back the water to a sufficient height to prevent any strong action or cross-current over the former. There is one case of this kind at The Trap."

This transverse or cross-dam was constructed at an angle of 45° to the current, and extended from the left bank to meet the main work about 3,000 feet from the head. This had the desired effect. In 1867 extensive repairs were made to the general work, 15,500 cubic yards of stone being used. Repairs again becoming necessary and there being much objection to a wall of rough stone against which barges and boats were frequently injured, a system of crib-work was devised and work was begun on it in September, 1876, and at the close of the working season the repairs were completed for a distance of 985 feet. In July, 1877, operations were resumed and the dike was finished for a further distance of 1,808 feet, and the dam closing the chute between the tow-head and the foot of Neville Island was rebuilt.

The total length of this latter dam is 1,060 feet, of which 860 feet is of substantial crib-work ballasted with stone. It is 25 feet wide and is built to a height of 5 feet 3 inches above low-water. The total length of repairs to the dike is 2,793 feet, extending to a point 100 feet above the junction of the dike with the cross-dam. The dike is 20 feet wide, and is built to a height of 6 feet above low-water, by means of a well-ballasted crib-work having a smooth surface on the channel side. From the end of the crib-work to the junction of the cross-dam with the dike, a gap has been made through the latter for the accommodation of the commerce of Middletown, a village on the left bank. This gap is, however, very difficult and even dangerous to navigate in its present state, owing to the strong current through it, but when the cross-dam below is finished to the height of the dike all this trouble will disappear.

The length of the cross-dam is about 800 feet, and the cost of raising it by a crib-work of similar construction to that of the dike is estimated at $10 per linear foot, or a total of $8,000. After this is done the repairs of the dike should be still further extended to the foot of The Trap, a distance of about 1,500 feet. The cost of this extension will be about $10,500, or $7 per linear foot.

The following statement shows the materials expended in the repairs of 1876 and 1877, with their cost, as well as the cost per linear foot of the work completed. A sketch is appended, showing the manner of construction and the location of the works.

FOR THE DIKE.

267,335 feet oak, at $17 to $21 per M	$4,989 29
80,712 feet pine, at $18 per M	1,452 81
19,849 feet hemlock, at $11.95 to $13 per M	248 27
60,026 pounds bolts, at 2¼ to 2¾ cents per pound	1,416 24
1,487 pounds spikes, at 3 to 4 cents per pound	51 49
182 pounds plate-iron, at 6¼ cents per pound	11 83
128 pounds ring-bolts, at 8 cents per pound	10 24
4,785.5 cubic yards slag, at 49 to 70 cents per cubic yard	2,738 96
2,552.5 cubic yards stone, at 50 cents to $1 per cubic yard	1,703 12
Freight on 57,700 pounds iron, at 12½ cents per cwt	72 10
Tools and implements	25 14
Towing boats	23 00
Labor	5,046 26
Total cost	17,788 75

Average height of new work	5 feet.
Length of crib-work	2,793 feet.
Cost per linear foot	$6 37.

MIDDLETOWN

MILL

MILL

NEVILLE ISLAND

TOWNHEAD

THE TRAP

WHITE'S RIPPLE

MERRIMAN'S BAR

P. FT. W. & CH. R. R.

11 MILES BELOW PITTSBURGH

HAY'S RUN

12 MILES

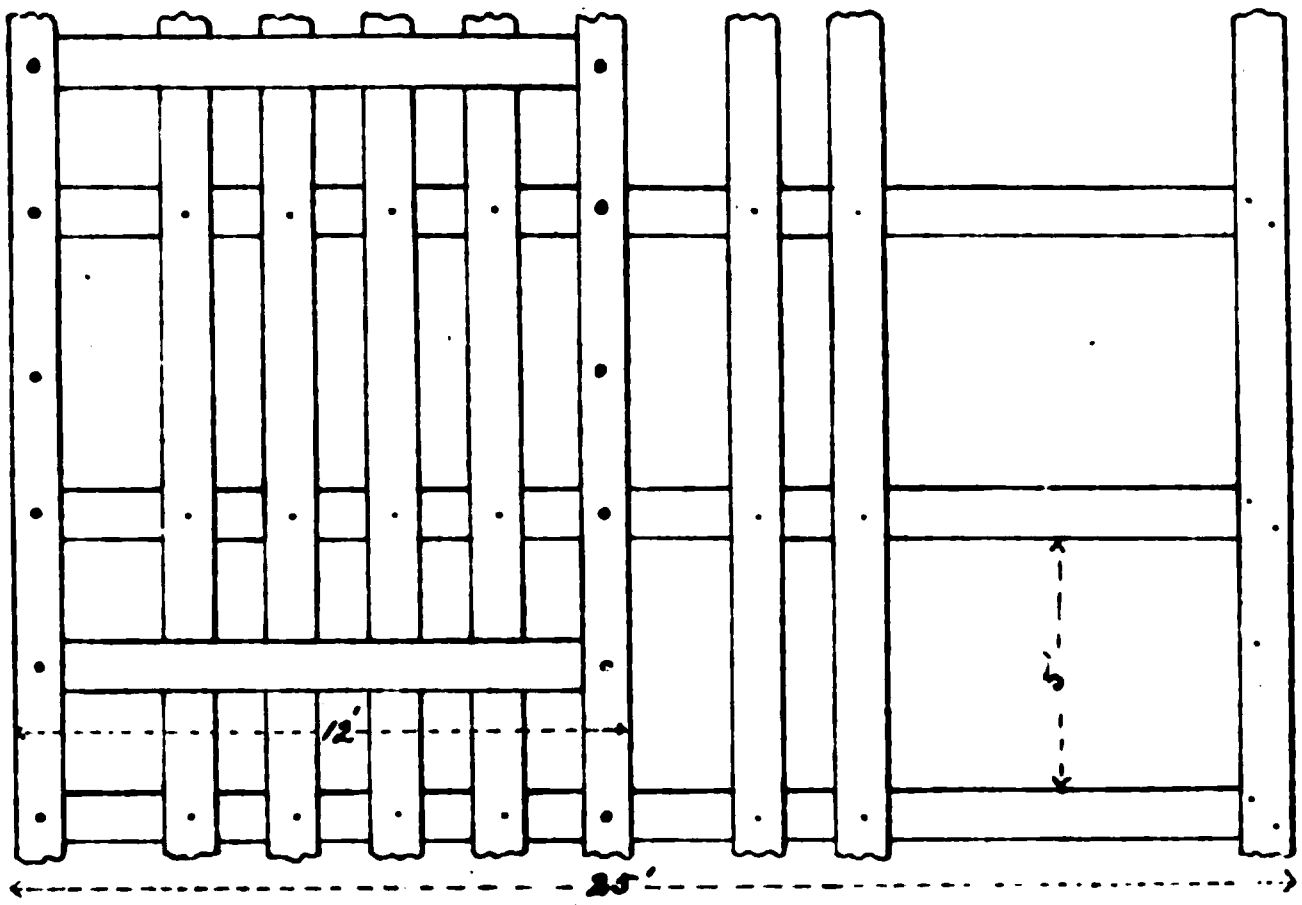
MAG. MER. N

NEW WORK SHOWN BY DOUBLE LINE: ═══

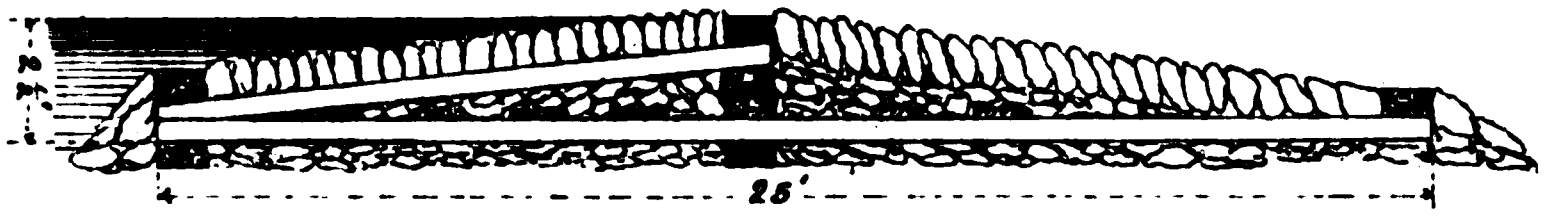
SCALE.

1000 0 1000 2000 3000 4000 ft.

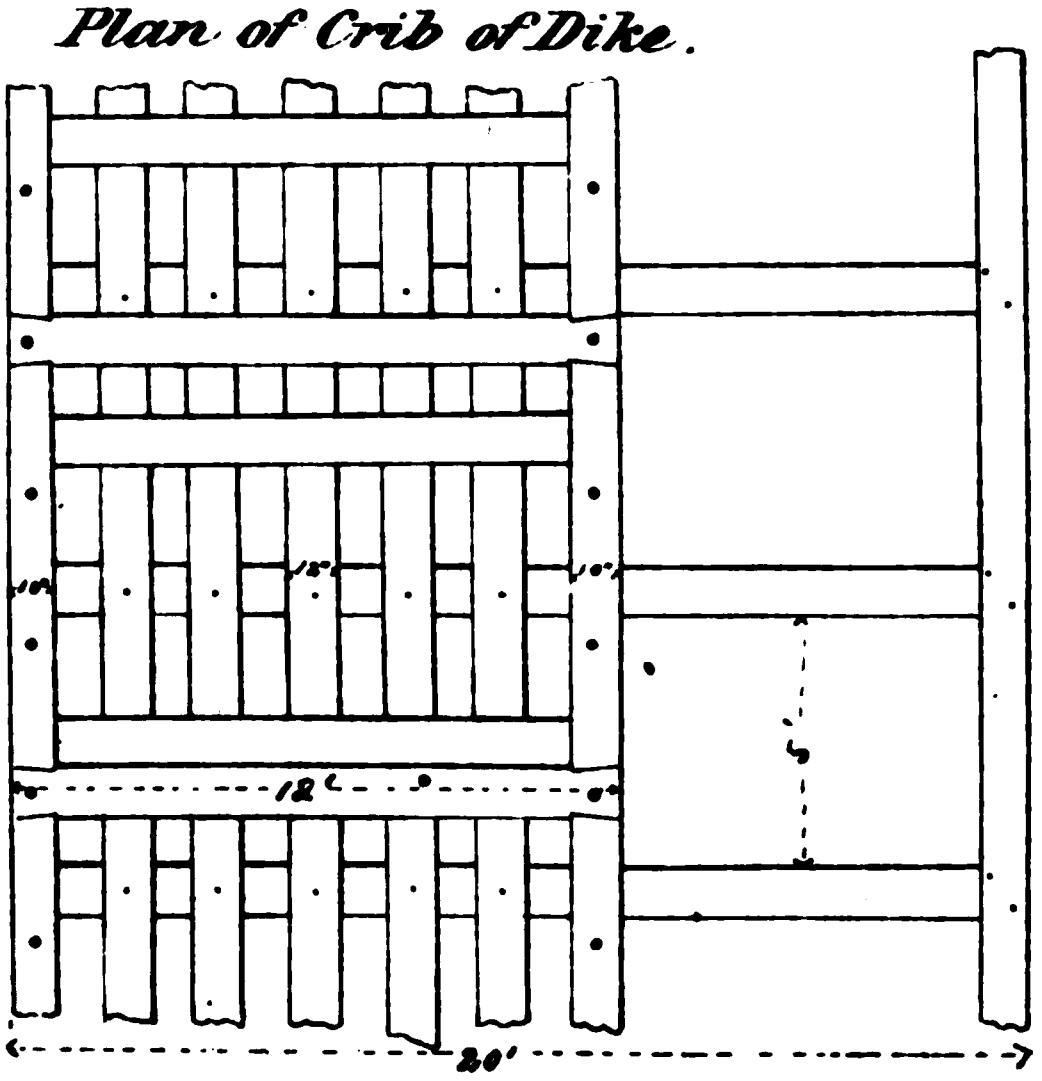
Plan of Crib of Dam.



Section – Completed.



Plan of Crib of Dike.



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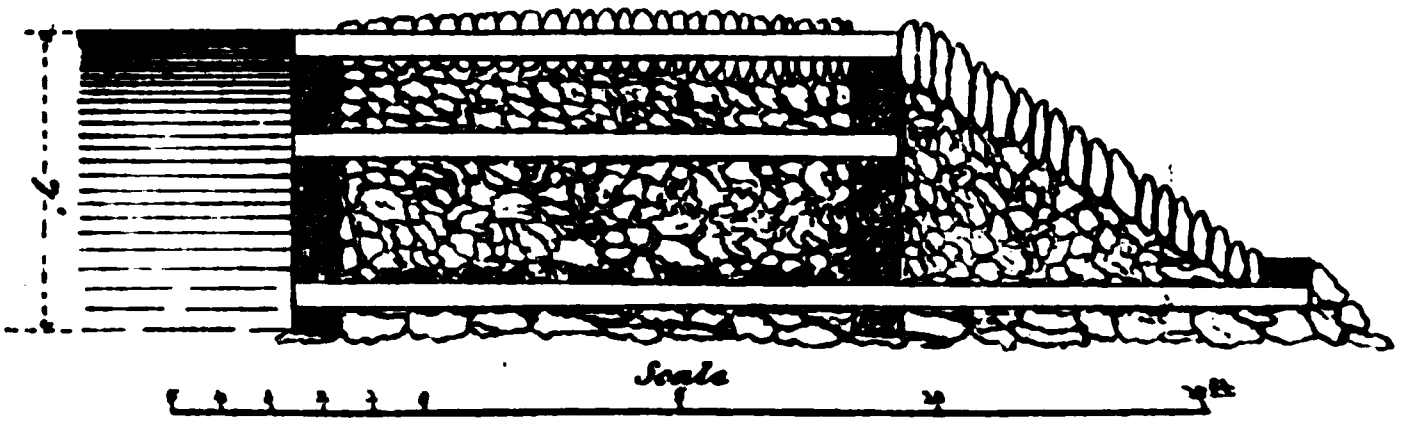

FOR THE DAM.

55,747 feet oak, at $17 to $18 per M	$1,002 00
10,320 feet pine, at $18 per M	185 76
13,074 feet hemlock, at $11.95 per M	156 23
6,814 pounds bolts, at 2¼ cents per pound	153 32
253 pounds spikes, at 3½ cents per pound	8 85
644 cubic yards slag, at 49 cents per cubic yard	315 56
1,014.5 cubic yards stone, at 60 cents per cubic yard	608 70
Freight on 6,200 pounds iron, at 12½ cents per cwt	7 75
Labor	1,517 93
Total cost	3,956 10
Average height of work	3. 3 feet.
Length	1,060 feet.
Cost per linear foot	$3 73

REMOVING ROCKS.

Many complaints being made about the existence of rocks in various parts of the river, a steamboat, the Argo, with one crane boat, was employed on the 11th of August to work between Marietta and Portsmouth. Another steamboat, the Orion, began work near Pittsburgh on the 3d of August. The *Argo* quit work October 6 and the *Orion* October 9. During this time these two boats worked over 346 miles of the river and removed more than 1,600 rocks, many of which would weigh from 15 to 20 tons. Other rocks were broken in pieces and leveled down.

In addition to these boats a party of men with horses and a drag-sled was employed at Brunot's Island, Horsetail, Lowrie's, Duff's, Merriman's, and White's. This party removed 2,787 rocks from these bars.

SNAG-BOAT E. A. WOODRUFF.

For the reasons given by Maj. W. E. Merrill in his last annual report (Report of the Chief of Engineers for 1877, Part 1, page 627) the work done by the snag-boat during the entire season of 1877 is here given, which of course includes a part of the fiscal year ending June 30, 1877.

The season's work began June 5 and ended December 6, 1877. On the latter date the boat went out of commission and was laid up for the winter in the mouth of Green River, Kentucky. During the season she worked over the river as follows:

1. Cincinnati to Pittsburgh.
2. Pittsburgh to Cairo.
3. Cairo to Parkersburg.
4. Parkersburg to winter quarters in the mouth of Green River.

The sum of the season's work was 1,037 snags and 50 wrecks of barges. The aggregate weight of the snags was 8,885 tons, making the average weight of a snag 8½ tons.

The distance run was 2,990 miles.

The following table shows the work of the boat in detail:

Week ending—		Snags removed.	Weight of snags removed, tons.	Wrecks removed.	Miles run.	Remarks.
June	9	9	123	3	176	Cincinnati to South Point, Ohio.
	16	12	31	4	358½	South Point to Walker's Station, Ohio.
	23	31	166	8	161½	Walker's Station to Murraysville, W. Va.
	30	55	409	1	114½	Murraysville to Four Pole Creek, W. Va.
July	7	53	450	1	157½	Four Pole Creek to Cincinnati.
	14	.....	.....	.....	.....	Repairing boat at Cincinnati.
	21	27	129	11	112	Cincinnati to Bush's farm, Ind.
	28	54	396	3	142	Bush's farm to Cannelton, Ind.
Aug.	4	76	603	.....	81½	Cannelton to Henderson Bend.
	11	73	996	.....	29½	Henderson Bend to Slim Island.
	18	57	994	.....	64½	Slim Island to Big Hurricane, Ind.
	25	43	589	2	47½	Big Hurricane, Ind., to Paducah, Ky.
Sept.	1	41	414	2	133½	Paducah to Pryor's Island.
	8	50	476	1	60	Pryor's Island to Wabash River.
	15	57	405	.....	62½	Wabash River to Three Mile, Ind.
	22	58	447	.....	92½	Three Mile, Ind., to Harrison's Landing.
	29	42	358	.....	79½	Harrison's Landing to New Albany.
Oct.	6	49	245	.....	47	New Albany to West Louisville.
	13	.....	.....	.....	6½	Laid up; low water.
	20	56	308	1	79	West Louisville to Patriot.
	27	69	516	2	52	Patriot to Cincinnati.
Nov.	3	.....	.....	1	4½	Repairing boat at Cincinnati.
	10	49	217	5	67½	Cincinnati to Palestine, Ohio.
	17	25	175	5	97	Palestine to Portsmouth, Ohio.
	24	36	322	1	115½	Portsmouth to Riverside, Ohio.
Dec.	1	11	96	.....	339½	Riverside to Cincinnati.
	8	4	20	.....	308½	Cincinnati to Green River.
		1,037	8,885	51	2,990½	

DREDGING.

The dredges Ohio and Oswego were at work continuously from July 2 to December 1, 1877.

On the 6th of April they went to the Wabash and were engaged on that river under direction of Maj. J. A. Smith, Corps of Engineers, until June 24, 1878.

CINCINNATI.

Before starting out the dredges removed the wreck of a coal-barge at the foot of Ludlow street.

RACCOON ISLAND.

(273 miles below Pittsburgh.)

The object of dredging at this point was to remove a lump between the two channels of the river. This work it was supposed had been finished during the preceding season, or so nearly completed that the current would finish the removal of the lump, but time had shown the need of further dredging to complete the improvement. Work began here on the 2d of July and ended on the 21st. The number of days actually at work was but 7, during which time the lump was removed. The result of this work was the widening of the channel about 200 feet, besides straightening it considerably.

Excavation made, 4,568.7 cubic yards.

GALLIPOLIS ISLAND.

(267 miles below Pittsburgh.)

After leaving Raccoon Island the dredges began work at Gallipolis Island, with a view to widening the channel so as to relieve tows from

the necessity of making a very square crossing from the island to the Virginia shore. Enough of the bar was removed to make the low-water channel about 450 feet wide. The channel was also very much straightened.

The wrecks that were said to have caused the bar were removed, and it seems probable that the current will now restore the channel to the middle of the river, which appears to be its normal position at this point.

Work began here on the 22d of July and ended on the 30th of August. The number of days actually at work was 26½.

Excavation made, 34,851.5 cubic yards.

FOOT OF RACCOON ISLAND.

(274 miles below Pittsburgh.)

After finishing at Gallipolis Island, the dredges went to Raccoon Island to straighten the channel by the removal of a lump on the island side just above Crab Creek Bar. This work was not of much importance, but was taken in hand because there was not sufficient water to permit of taking the dredges to more important points. They worked here from August 31 to September 4, when the river rose sufficiently to let the dredges go elsewhere.

Excavation made, 2,145 cubic yards.

CULLUM'S RIPPLE.

(471¼ miles from Pittsburgh.)

The dredges next went to Cullum's Ripple, where the channel was very narrow and navigation rendered difficult by the projection of a rocky point or bar formed at the mouth of a small creek on the Ohio shore about the middle of the ripple. The low-water channel here has been widened about 65 feet at the upper end of the ripple by removing a part of the bar on the left; and the rocky point referred to has been entirely removed. In this way the channel has been straightened and made some 90 feet wider than before. Six snags and one wreck were also removed by the dredges at this point. The dredges worked here 23.5 days.

Excavation made, 13,245 cubic yards loose rock and 10,581 cubic yards gravel.

CINCINNATI SOUTHERN RAILROAD BRIDGE.

By authority of the Secretary of War (letter Chief of Engineers, October 3, 1877), the dredges were employed from October 6 to October 10 in removing the crib-work and riprap from around the channel-piers of the Cincinnati Southern Railroad Bridge.

Excavation made, 1,314 cubic yards loose rock.

CUMBERLAND DAM.

(907 miles below Pittsburgh.)

After completing the work at the Cincinnati Southern Railroad Bridge the dredges went to Cumberland Dam, it having been found that the gap made last season was not deep enough, and that the rock-piles marking the limits of the gap were dangerous to navigation. Work was begun on the 25th of October and ended December 1. The gap has been so much enlarged that it is not thought that any further difficulty will be found there. The channel through the dam is now 660 feet wide, measured at right angles to the current, and 720 feet wide measured along

the dam. The minimum depth at low-water is 5½ feet. For a width of 250 feet, beginning 30 feet from Dog Island, the channel has a minimum depth of 6½ feet. Time at work, 27½ days.

Excavation made, 16,488 cubic yards loose rock.

The following tables show the details of the work done by the dredges. The Wabash River work and the work done at the Cincinnati Southern Railroad Bridge, not being paid for from the appropriation for improving the Ohio River, are omitted from the tables.

DREDGES IN COMMISSION, 1877.

	Days.
Time at work:	
Ordinary dredging	45.5
Loose rock excavation	40.5
Wrecking and snagging	6.5
Time lost:	
Traveling	19
Accidents	7
High and low water	3
Sundays	26
Total	157

	Cubic yards.
Work done:	
Gravel excavation during season	52,146.2
Gravel excavation per day at work	1,124.1
Loose rock excavation during season	29,733.1
Loose rock excavation per day at work	734.1
Wrecks removed	8
Snags removed	12
Cost:	
Equipment:	
While in commission	$981 20
Per day at work	10 61
Per day in commission	6 25
Towing:	
While in commission	$7,238 20
Per day at work	78 24
Per day in commission	46 10
Salaries:	
While in commission	$8,981 88
Per day at work	97 10
Per day in commission	57 21
Repairs:	
While in commission	$524 48
Per day at work	5 67
Per day in commission	3 34
Totals:	
For dredging	$11,113 40
For loose rock excavation	9,892 15
For wrecking and snagging	1,587 63
Per day at work	244 25
Per day in commission	143 90
Per cubic yard of gravel excavated	21⅞
Per cubic yard of loose rock excavated	33¼

DREDGES OUT OF COMMISSION.

	Days.
Time:	
In ordinary	116
Annual spring repairs	65
Total	181
Cost:	
Salaries	$1,015 67
Towing (Wabash River to Cincinnati)	1,205 00
Annual spring repairs	3,145 67
Total	5,366 34

	Miles from Pittsburgh.	Place.	Kind of work.	Days at work.	Excavation.				Expenditures.			
					Cubic yards of sand, gravel, &c.	Cubic yards of loose rock.	Cubic yards per day at work.	Cost per cubic yard.	Total for ordinary dredging.	Total for dredging loose rock.	Total for wrecking.	Grand total.
1877.												
June	466	Cincinnati, Ohio	Wrecking	1							$244 25	$244 25
June and July	273	Head of Raccoon Island	Dredging	7	4,568.7		652.7	$0.374	$1,709 76			1,709 76
July and August	267	Foot of Gallipolis Island	....do	26½	34,851.5		1,315.1	0.185	6,472 64			6,472 64
August and September	267	.....do	Wrecking, &c	2							488 50	488 50
August	267½	Gallipolis, Ohio	....do	1							244 25	244 25
August and September	274	Foot of Raccoon Island	Dredging	3	2,145.0		715.0	0.341	732 75			732 75
September and October	471½	Cullum's Ripple	....do	13		13,244.9	1,018.8	0.240		$3,175 26		3,175 26
September and October	471½	.....do	....do	9	10,581.0		1,175.7	0.208	2,198 25			2,198 25
October	471½	.....do	Wrecking, &c	1½							366 38	366 38
October and November	907	Cumberland Dam	Dredging	27½		16,488.2	599.6	0.407		6,716 89		6,716 89
October	907	.....do	Wrecking, &c	1							244 25	244 25
				92.5	52,146.2	29,733.1	952.1	.....	11,113 40	9,892 15	1,587 63	22,593 18

The [illegible] dredge [illegible] in [illegible] and [illegible] during the [illegible] it will [illegible] the present season. The machinery of this dredge is still in the [illegible] and [illegible] repairs.

MOVABLE DAM AT DAVIS'S ISLAND.

After many delays and much trouble the land for the first movable dam has been bought and paid for. The payment was made on May 13, 1878, and the deeds for the property, after having been recorded in the office of the recorder of Allegheny County, Pennsylvania, were sent to the Chief of Engineers on June 21, 1878.

SPECIAL SURVEYS.

The following surveys were made during the year:

1. Survey for Ice Harbor at Cincinnati.
2. Survey of Letart Falls.
3. Survey of Kanawha Bar.
4. Survey of Portland Bar.
5. Survey of harbor at Evansville, Ind.

Of these the maps are all completed, and tracings of them are now being made.

The report on the ice-harbor, together with explanatory map, was forwarded to the Chief of Engineers on December 20, 1877.

OFFICE WORK.

Work in the office has included working up maps of surveys, preparing drawings for lock and dam at Davis's Island, and making plans for the repairs of the snag-boat and dredges. Hydrographs have been constructed from the gauge records kept at various points on the river, and a large number of drawings have, for their better preservation, been mounted on cloth.

No mention is made of the work authorized during the present season, nor is any estimate given for the fiscal year 1879–'80, as these matters seem more properly to belong to Major Merrill, who resumed charge of the work a few days after the close of the fiscal year.

Money statement.

July 1, 1877, amount available, including $6,924 due on outstanding liabilities	$151,443 36	
Amount appropriated by act approved June 18, 1878	300,000 00	
		$451,443 36
July 1, 1878, amount expended during fiscal year	91,336 31	
July 1, 1878, outstanding liabilities	391 72	
		91,728 03
July 1, 1878, amount available		359,715 33
Amount that can be profitably expended in fiscal year ending June 30, 1880		500,000 00

SPECIAL REPORT OF BOARD OF ENGINEERS ON PROPOSED MOVABLE DAM AT DAVIS'S ISLAND, OHIO RIVER.

CINCINNATI, OHIO, *January* 25, 1878.

GENERAL: The Board of Engineer Officers appointed by Special Orders No. 5, dated headquarters Corps of Engineers, Washington, D. C., January 15, 1878, have the honor to submit the following report:

In accordance with the above order the Board met at Cincinnati on

the 24th instant, all the members being present except Major Craighill, who telegraphed that he could not attend.

The instructions contained in the order were—

To examine and report upon the plan of a lock and gate proposed to be substituted by Major Merrill for the lock and gate heretofore approved in connection with the construction of the first "movable dam" on the Ohio River below Pittsburgh.

The special instructions to the Board, contained in a letter of January 16, from the Chief of Engineers to the presiding officer of the Board, state that it—

Is authorized, in addition to the duties prescribed by the order, to consider and report upon any questions relating to the movable dam proposed to be constructed on the Ohio River below Pittsburgh as may, in the judgment of the Board, be deemed essential in further illustration of, or in extension of, or in modification of the report of the Board dated April 19, 1875.

In accordance with the above orders, the Board have carefully studied the whole subject of the proposed movable dam at Davis's Island, near Pittsburgh, and have concluded that no change is needed in the former report on this subject, excepting the part that relates to the lock. The officer in charge does not desire any modification in the plans for the dam that were then approved, nor do the Board see any reason for changing the former conclusions on this part of the work.

The plan for a lock which was presented to the Board in April, 1875, nearly three years ago, contemplated a width in the clear of 78 feet and an available length of 630 feet. It was expected to accommodate a fleet of 9 coal barges in 3 ranks of 3 in a rank, a tow-boat in rear of the fleet, and a small fuel flat. It was known even then that coal fleets are not usually made up in this manner, but the lock proposed was believed to be as wide as it was practicable to make it with miter gates of such limited height. It was expected that the coal trade would adapt itself to the lock, and that no serious trouble would ensue.

Not long after this report was made, opposition to the whole method of improvement sprang up among coal-shippers, and it became desirable to remove any ground of opposition.

It was expected that work of construction would be begun in the summer of 1875, but owing to the failure of the legislature of Pennsylvania to pass an act ceding jurisdiction to the United States over the lands required for the lock and abutments, nothing could be done. In the spring of 1877 the act in question was passed, and the interval since then has been spent in negotiating for the necessary lands and in securing the approval of the Attorney-General to the validity of the titles. These matters, however, are well under way, and so soon as this approval is obtained work can be begun at once.

Meanwhile the officer in charge, recognizing the force of the objections to the lock as approved, endeavored to overcome them by an increase in width. After long investigation he finally decided to recommend a gate, somewhat resembling a railroad car, which, when out of use, is housed in a recess in the bank, and when needed is run across the lock, thus shutting it up and acting as a gate.

The drawings and calculations of this gate have been submitted to us, and we have carefully examined a very well-built model.

We have no hesitation in affirming our belief that this gate will work satisfactorily, and that it is specially suitable to very wide locks with low heights of wall.

The proposition now submitted by the engineer in charge is to make the lock wide enough to admit the normal coal fleet of ten barges and a tow-boat. This will require a neat width of 100 feet, and if 10 feet be

allowed for clearance (which is none too great for so cumbersome a mass as a coal fleet), it will call for a lock 110 feet wide in the clear. This change in width makes it unnecessary to have an available length of more than 600 feet, which is a reduction of 30 feet in the available length originally proposed. An additional saving in length arises from the fact that the width of the lower gate as now designed is 32.5 feet less than the length of the recess for the lower gate of the 78-feet lock. The width of the upper gate is 34.5 feet less than the length of the recess for the upper gate of the 78-feet lock. The total saving in the length of the lock-walls will therefore be 134 feet, which saving will probably about counterbalance the increased cost due to the gate recesses, which are not in the original plan.

The plans submitted to us are for a lock of this width, closed at each end by a straight running gate 117 feet long, having a lap of 3.5 feet on each wall.

The power to move these gates and to maneuver the valves for filling and emptying the lock-chamber is to be a small steam-engine of not to exceed 10 horse-power. It would seem at first thought that it would be better to utilize the power created by the dam, but a careful calculation, which has been submitted to us, has shown that the first cost of the structures necessary to establish turbines is so great that steam is the cheaper of the two. Moreover, there are times when power is needed for pumping and other work when the dam is down and turbines could not be set in motion. Another advantage is that steam-engines are always visible and accessible for repairs, and being in more general use than turbines it is much easier to get competent men to manage them. The proximity of the dam to the great iron and coal city of Pittsburgh seems to indicate steam as the natural and proper motor at this work. We therefore recommend the use of steam instead of water power for moving the gates and for other similar work about the lock.

The arrangements for filling and emptying the lock seem to be well designed to serve their purpose, and also to prevent any accumulations in the gate recesses that might interfere with the free movement of the gates.

The short section of movable dam across the head of the lock is apparently a necessary adjunct in order to insure the safe withdrawal of both gates in times of flood, and their re-establishment across the lock when the floods have subsided. Should experience show that the gates can be maneuvered without it, the wickets can be utilized on the weir of another dam.

In approving of the plans that have been laid before us, the Board desire to limit their approval to the general design and method of accomplishing the object of the work. They think that the engineer in charge should have great latitude in all the details, as time and experience are constantly suggesting minor changes and modifications which the engineer should be at full liberty to adopt without the formality and loss of time required to submit a formal application for authority. The very plans which we are now discussing are a proof that improvements are constantly suggesting themselves in any large work, even before it is begun. It is probable that many others will become evident during the actual work of construction.

Accompanying this report is a tracing of the lock and its appurtenances. It was not considered necessary to give the details of all the minor parts, for the reason suggested above.

We would recommend that the engineer in charge investigate the propriety of using iron instead of wooden trusses for the lock-gates. Either material will accomplish its purpose satisfactorily, and we would there-

fore leave the selection to him, subject, of course, to the approval of the Chief of Engineers.

Very respectfully, your obedient servants,

H. G. WRIGHT,
Lieut. Col. of Engineers, Bvt. Maj.-Gen.
G. WEITZEL,
Major of Engineers, Bvt. Maj.-Gen.
O. M. POE,
Major of Engineers, Bvt. Brig. Gen.
WM. E. MERRILL,
Major of Engineers, Bvt. Colonel.
F. A. MAHAN,
First Lieutenant of Engineers, Recorder.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

[First indorsement.]

OFFICE OF CHIEF OF ENGINEERS,
February 4, 1878.

Respectfully submitted to the honorable the Secretary of War in connection with the question of the construction of the first movable dam across the Ohio River below Pittsburgh, provided for by the river and harbor act of March 3, 1875. A report upon this subject was made by a Board of Engineer Officers constituted for the purpose, which was approved by the Secretary of War May 5, 1875.

Further investigation of the subject, pending the settlement of preliminary matters before commencing the work, has induced Maj. Wm. E. Merrill, Corps of Engineers, the officer in charge, to propose an alteration of the plan heretofore approved, so far as it relates to the dimensions of the lock and the construction of lock-gates. This proposed change in the plan was submitted for investigation to a Board of Engineer Officers and the result is given in the within report.

It will be seen that the Board approves the proposed change in the lock and lock-gates. Its views are concurred in by me and are respectfully recommended for approval.

* * * * * * *

A. A. HUMPHREYS,
Brig. Gen. and Chief of Engineers.

[Second indorsement.]

The recommendation of the Chief of Engineers is approved.
By order of the Secretary of War.

JOHN TWEEDALE,
Acting Chief Clerk.

FEBRUARY 9, 1878.

U 2.

IMPROVING UPPER MONONGAHELA RIVER, WEST VIRGINIA.

Nothing was done on the works on this river during the past year, owing to lack of funds. The condition of the work is given in Major Merrill's last annual report (Report of the Chief of Engineers for 1877, Part I, page 662).

Major Merrill further says:

It is also important to begin as soon as possible the lock at Laurel Run, 2 miles below the mouth of Cheat River. When this lock is finished (which is No. 8 of the series beginning at Pittsburgh), the Monongahela Navigation Company will put in No. 7, and then there will be a complete slackwater navigation from Pittsburgh to Morgantown, 102 miles. The lock at Laurel Run, with keeper's house and all accessories, will cost about $115,000, the increase over the Hoard's Rock lock being due to the greater depth and expense of foundation.

ESTIMATE FOR 1879–'80.

For lock at Laurel Run	$115,000 00

Money statement.

July 1, 1877, amount available	$519 54	
Amount appropriated by act approved June 18, 1878	25,000 00	
		$25,519 54
July 1, 1878, amount expended during fiscal year	240 00	
July 1, 1878, outstanding liabilities	2,903 15	
		3,143 15
July 1, 1878, amount available		22,376 39
Amount that can be profitably expended in fiscal year ending June 30, 1880		115,000 00

U 3.

IMPROVEMENT OF LITTLE KANAWHA RIVER, WEST VIRGINIA.

The Little Kanawha drains an area estimated at 3,200 square miles. The character of its basin is such that the rain-fall, except what is absorbed by the ground, is quickly carried off by the river and its tributaries. A general rain in the basin is followed by a rise that generally is of but short duration. Sometimes when a heavy rain occurs in the valley of a tributary the water coming from it carries a large amount of sediment, which, being deposited, frequently forms a bar in the stream at the mouth of the tributary.

During the dry season the Little Kanawha is fed by mountain springs, but these do not supply sufficient water to keep up a continuous navigation.

The present use of the unimproved part of the river is to run out lumber. The finest qualities of poplar, oak, hickory, beech, maple, birch, gum, linn, and walnut are found.

This timber must be cut and stored, and then kept until a rise. As everybody must do this, it naturally follows that after each rise there is a glut in the markets supplied from these sources, and consequently the lumber must be sold at prices that hardly pay for getting it out and transporting it.

This valley is very rich in fine iron-ores. Good limestone is also found in abundance. It is said that copper and saltpeter have also been found, but the quantity and quality of these last have not been given.

Plenty of coal is found throughout this basin, varying in thickness from 4 to 12 feet. In the present condition of the river this coal cannot compete with that which comes from Pittsburgh. The only remedy for this, as well as for the difficulties about lumber, is to slackwater the river. Were slackwater established, the cost of towing would probably not exceed that on the Monongahela, although this would depend, in some measure, upon the amount of towing to be done.

The great obstacles to the navigation of this stream are lack of water and leaning trees. During the periods of high water, when the currents are swift, the sand is carried away from the roots of the trees, which consequently lean over to a greater or less extent. In rivers of ordinary width this might do little or no harm, but where the stream is narrow these trees become a great obstacle to the passage of boats. Sometimes these leaning trees are entirely undermined and carried away by the current. If they happen to be caught at any shoal point they become dangerous as snags. At other times, when caught, they form the nucleus of bars, and in this case they present a very great obstruction to improvement, because it becomes necessary to remove not only the rack-heap but the bar also that has formed about it.

On account of the sinuosity of the river both bars and islands become great obstacles to navigation by reducing so much the width of the stream. The thick undergrowth of brush upon the bars and islands has caused their enlargement by collecting and holding the sedimentary deposits of the freshets.

The three mill-dams above Glenville present great obstacles to the navigation of the upper river. These dams are only passable by boats when there is a rise of at least 8 feet. The consequence is that raftsmen are often prevented from taking advantage of water otherwise suitable, on account of the depth being insufficient to float them over these artificial obstructions.

Last, but not least, must be mentioned the many large rocks scattered over the bed of this river. There would often be sufficient water to make nearly all other obstructions disappear, but the current of this river is so rapid during these freshets that it is almost impossible for loaded boats to pass the projecting rocks in the sharp bends without being stove up.

Mr. Bell, the engineer in charge of the work on this stream during the summer of 1877, reports as follows:

> The improvements on this river have been made with a view of bettering its present navigable condition as far as practicable with the available funds. Before describing the manner of removing the obstructions to navigation, it will be necessary to state that this improvement was not undertaken with the view of obtaining a depth of water sufficient for steamboat navigation, but simply to remove such obstructions as impeded the running out of the timber products of this valley.
>
> After the examination of the Beaver and Nailor Bend rocks with a view to preparing specifications for their removal by contract, I began to work upon the improvement of the river at Buffalo Shoals, the first serious obstruction below Lumberport, the practical head of navigation for rafts. The improvement consisted in building a brush and stone wing-dam to the island in the middle of the shoal, and in plowing and scraping the gravel-bed of the left-hand chute. All the water is now confined to one channel, which, since its improvement, has increased in depth nearly 2 feet.
>
> The work from Bulltown to this shoal consisted in the removal of such leaning trees and snags as had a tendency to catch floating logs that were on their way to be formed into rafts in the vicinity of Lumberport.
>
> It was thought inadvisable to expend much money upon the upper river, so long as the most serious obstructions still remained in the shape of mill-dams, which have a legalized existence. Consequently this part of the river received only such improvements as were absolutely necessary for the running out of timber. The most serious obstacles to navigation were found between Glenville and Grantsville, and the greater part of the summer was spent in removing them. This part of the river is narrow, and was greatly obstructed by leaning trees, snags, bars, islands, rocks, and shoals. The river from Grantsville to slackwater becomes wider and deeper from its many large tributaries. Consequently the obstructions to navigation are not so serious. The leaning trees were cleared from the banks, and cut up so as to be carried away by the next freshet. The removal of snags was undertaken during extreme low-water. The thick undergrowth of brush upon the bars and islands was grubbed and burned. The hard gravel crest of the bars was broken up by plowing, so as to better expose the loose matter underneath to the action of floods. A channel was in some instances cut through the bars to obtain the fullest erosive action. There are no serious rock ob-

structions now remaining on this river. The advantages given to navigation by their removal can only be realized by considering the great labor and loss they have hitherto occasioned to the timber interests.

Upon some of the shoals the improvement consisted in building wing-dams to concentrate the water into one chute during minimum stages. These dams have in every case given good satisfaction by confining the water into one navigable channel that was formerly spread over a wide area. Many of the shoals have a gravel bed, which was plowed and furrowed, and all loose rocks were removed from the channel and placed upon the wing-dams. Where islands existed it became necessary to close one of the chutes by means of a dam, in order to throw the entire volume of water into the main channel.

Since the completion of the improvements there have been two freshets, which have carried out immense quantities of drift and left the river comparatively free from timber obstructions. Many letters have been received from pilots employed on the river, all of whom speak favorably of the improvements made. The result of the work may be briefly stated thus: The most serious obstructions have been entirely or partially removed; a greater depth of water has been secured at the shoalest points; the duration of the rafting stages has been increased, and the labor and cost of rafting have been materially lessened.

The water supply of this valley being too irregular for sluice navigation, the only possible method of obtaining a constant depth sufficient for navigation is to adopt a slackwater system.

Subjoined are two tables, which show the amount of work done on this river. The first gives the names of the points where improvements have been made, and shows the nature of the work done, with explanatory remarks. The second gives a statement of the quantities of work done.

Table No. 1.

Miles from Parkersburg.	Name of place.	Description of work.	Remarks.
119½	Buffalo Shoal	A dam of brush and stone was built across the right-hand chute. All loose rock was removed. Channel was plowed and scraped.	The bed of this shoal is gravel. Dam is 50 by 3 by 2 feet high. The depth of water in channel has been increased 20 inches.
117	Stout's Island.....	Brush, drift, and trees were removed. Right-hand side and lower end of island plowed and scraped.	An immense pile of drift had lodged upon this island.
114	Cooper's Run Island.	Brush was removed. Island was plowed and scraped. Left-hand chute was widened and deepened.	
113¾	Niemer Rocks and Stout's Mill Rocks.	These are very dangerous rocks in bend of river.	
112¾	Garret Rocks.....	These rocks have caused considerable damage to boats. They are in bend at head of Dusk Camp Bar.	
112¾	Dusk Camp Bar	Brush was removed, bar was plowed and a channel was cut through it. Right-hand chute was closed by a dam.	The channel was 300 feet long, 15 feet wide, and 13 feet deep.
112¼	Stout's Bend Rocks.	These rocks were dangerous to navigation.	
110½	Burk's Island.....	Brush, trees and drift were removed.	Island was thickly covered with large trees. An immense pile of drift had collected at lower end of island.
	Floyd Bend Rocks..	These rocks were entirely removed..	These rocks were serious impediments to navigation.
106	Hay's Bar	Brush was removed. Bar was plowed, scraped, and channeled.	New channel 400 by 30 by 4 feet deep.
103	Glenville Rocks.....	.....	These rocks are in the vicinity of Glenville.
101½	Red Oak Bar.....	Brush and drift were removed. Bar was plowed, scraped, and channeled.	
92½	Picken's Bar.....	This bar was plowed and scraped....	A serious obstruction to navigation.
	Paddy's Rock.....	This rock was partially removed.	
91	Middle Run Bar....	Brush was removed and bar was plowed and furrowed.	
89	Muscle Shoals.....	A crib-dam was built from left bank to an island at foot of shoal. Point of rocks at head of shoal was removed. The channel was plowed.	This was the worst obstruction in the river. An increased depth of 2 feet has been obtained in channel since this improvement. Dimensions of dam are 650 feet long, base 12 feet, top 8 feet, and 3 feet high.

Table No. 1—Continued.

Miles from Parkesburg.	Name of place.	Description of work.	Remarks.
88¾	Martial Island.....	Island was plowed and scraped. Brush was grubbed and burned. Right-hand chute closed by a dam.	
88	Rafferty's Island.....	Brush was removed from this island. Point of rocks at foot of island was removed.	
87	Laurel Shoal.....	A dam of brush and stone closes the left-hand chute.	This is now the shallowest shoal on the river.
86	Acre Island.....	Brush, drift, and trees were removed. Right chute closed by a dam. Point of rocks at head of island removed.	Right-hand side of this island was thickly covered with trees. An immense pile of drift had lodged on this island.
82½	Steer Creek Shoals..	All loose rock in shoal was removed.	
80	Hoffman's Bar.....	Bar was plowed and brush was removed.	Point of rocks at foot of bar was removed.
77½	Leaf Bank Bar.....	Brush was removed. Bar was plowed and channeled.	The low-water channel is very crooked.
68½	Big Root Shoal.....	Bed of this shoal was plowed and loose rock was removed.	Point of rocks on right at foot of shoal was removed.
66½	Stocking Run Bar..	Brush was removed. Bar was plowed and channeled.	Point of rocks was removed.
	Maize Bend.....	The projecting rocks were removed.	
56	Lower Leading Islands.	Brush was removed; islands were plowed; right-hand chute was closed by a dam.	
55	Leeson's Rock.....	.....	A dangerous rock projecting into the river.
	County Line Rocks.	.....	These rocks were dangerous.
53½	Nailor Bend Rocks..	These rocks were removed entirely and fragments deposited below low-water surface.	These rocks were considered very dangerous to navigation.
	Katy Run Rocks....	These rocks were partially removed..	
52½	Beaver Rocks.....	These rocks were entirely removed to low-water surface.	These rocks were the worst obstructions on the river. They caused much damage and loss to navigation.
	West Bend Rocks...	.....	Serious obstructions to navigation.
	Scott Bend Rocks...	.....	
47½	West Fork Shoal....	A dam of brush and stone was built at head of shoal and one at foot. The first dam directed the water into the channel, while the other backed it up on the shallow places of the shoal. Many large rocks in the shoal, which were always dangerous to navigation, were removed.	Point of rocks on the left, as well as all the rocks on the banks near the shoal, were removed.
42	Spring Creek Island.	This island was grubbed and drift was removed.	

Table No. 2.

Description of work.	Quantities.
Dams built	2,282 cubic yards.
Rocks removed	4,113.8 cubic yards.
Earth removed	1,676 cubic yards.
Trees removed	3,128 cubic yards.
Snags removed	2,927 cubic yards.
Saplings removed	3,871 cubic yards.
Drift removed	46 cords.
Trees trimmed	735.
Acres grubbed	11¾.

The work to be done during the present season and the estimate for 1879–'80 are reported by Major Merrill, who assumed charge soon after the close of the fiscal year.

Money statement.

July 1, 1877, amount available, including $550 due on outstanding liabilities	$7,300 00	
Amount appropriated by act approved June 18, 1878	18,000 00	
		$25,300 00
July 1, 1878, amount expended during fiscal year		6,369 31
July 1, 1878, amount available		18,930 69
Amount that can be profitably expended in fiscal year ending June 30, 1880.		68,270 00

U 4.

WORK PROPOSED DURING THE PRESENT SEASON ON THE IMPROVEMENTS OF THE OHIO AND LITTLE KANAWHA RIVERS, WITH ESTIMATES FOR THE NEXT FISCAL YEAR, BY MAJOR WILLIAM E. MERRILL, CORPS OF ENGINEERS, IN CHARGE.

UNITED STATES ENGINEER OFFICE,
Cincinnati, August 30, 1878.

GENERAL: I have the honor to submit the following statement of the proposed work of the present season in connection with the improvement of the Ohio and the Little Kanawha rivers, together with an estimate of funds that will be required for these rivers during the fiscal year 1879–'80:

OHIO RIVER.

WORK OF THE PRESENT SEASON.

The appropriation of June 18, 1878, has been allotted as follows:

Improvement of Grand Chain (specially allotted by appropriation act)	$50,000 00
Movable dam at Davis's Island	125,000 00
Completion of dike at The Trap	18,000 00
Repair of dike opposite foot of Blennerhassett Island	1,100 00
Extension of Evansville dike	12,500 00
Removing rocks from river between Pittsburgh and Cincinnati	9,000 00
Expenses of snag-boat, dredges, and office	82,000 00
Contingencies	2,400 00
Total	300,000 00

ESTIMATE FOR YEAR ENDING JUNE 30, 1880.

As stated in my last annual report, no allowance was made in the original estimate for the movable dam at Davis's Island for the cost of land, as there was apparently no way of determining its value. This land has since been purchased at a cost of $14,043. Adding the legal expenses attending the purchase, estimated at $550, we shall have $14,593 as the total cost of the land.

The cost of a lock-keeper's house was also omitted in the estimate. Such a house must be built ultimately should the work prove a success. Temporary buildings for an office and store-rooms will, however, be used until the lock and dam shall have been tested, and therefore no estimate is now submitted for a permanent building.

Estimated cost of movable dam	$465,000 00
Cost of site	14,593 00
Total	479,593 00
Already appropriated	225,000 00
Amount required for completion	254,593 00

There are many places on the Ohio River where dikes for controlling the currents are greatly needed, especially at Four Mile, Portland Bar, Puppy Creek, and Caseyville. Owing to the character of the work and the accidents liable to occur in the course of construction, it is very difficult to make exact estimates of cost.

Taking the cost of the French Island dike, however, as a basis, we shall have the following approximate estimate:

Four Mile, 1,500 feet, at $15	$22,500 00
Portland, 1,200 feet, at $15	18,000 00
Puppy Creek, 2,500 feet, at $15	37,500 00
Caseyville, 2,500 feet, at $15	37,500 00
Total	115,500 00

Each of these works would benefit a large amount of commerce. Four Mile Bar is ten miles above Cincinnati. Portland Bar is just below the falls at Louisville. Puppy Creek Bar is between Rockport and Owensborough; and Caseyville Bar is opposite the town of that name.

It is quite probable that another dike will be required at Four Mile, and that the dikes at each of the other places will ultimately require extension; but it is inadvisable to do more in one season than is indicated above.

In the Ohio River there are twenty-four wrecks of steamboats and model barges, twenty of which are obstructions to navigation, and should be removed. This can only be done by blowing them up with powder. The snag-boat is not designed for this class of work, nor has she time to spare from her legitimate duty of removing snags and the smaller wrecks of coal-barges. It is therefore proposed to do this work by contract. The cost is estimated at $20,000, or an average of $1,000 per wreck.

The wooden hull of the dredge-boat Ohio, which has been in service seven years, is now worn out, and it is proposed to remove her machinery to a new hull built of iron. The reasons for preferring an iron hull are thus set forth by Mr. E. J. Carpenter, assistant engineer in charge of the dredges:

> The hull of the United States dredge Ohio is worn out and cannot be made to last longer than through the present season. It will be necessary to build a new hull for the dredge, and in accordance with your instructions I have made the following statement of the relative merits and cost of wooden and iron hulls.
>
> The engines, boiler, and machinery on the dredge are good, although they will require some repairs before being placed on a new hull.
>
> It will be advisable to add to the machinery a pair of engines to run the capstans, and hoist the forward spuds, experience on the *Oswego* having shown that they greatly facilitate the handling of the boat and thus increase her capacity for work.

The following are the dimensions of the two Ohio River dredges, with their draught of water when new and at the present time:

Dredge.	Length.	Width.	Depth.	Draught.
Ohio	70 feet	28 feet	5 feet 9 inches	34 inches, 1871; 47 inches, 1878.
Oswego	75 feet	30 feet	6 feet 0 inch	31 inches, 1873; 37 inches, 1878.

As the dredges are employed almost exclusively during the low-water season and in dredging shallow bars, it is essential to successful work that they should be of the least possible draught. Experience has shown that this should not exceed 30 inches, and that if possible to build a dredge that would only draw 2 feet, its efficiency would be greatly increased.

With this object in view, I propose to make the new hull 20 feet longer and 3½ feet wider, thus giving an area of bottom of 2,835 square feet, instead of the present bottom area of 1,960 square feet. I also propose to retain the necessary stiffness of hull, and to give more room to handle coal by increasing the depth of hull to 6½ feet.

If the new hull of these dimensions (90 feet by 31 feet 6 inches, by 6 feet 4 inches) be built of wood, the dredge in complete order for service with coal aboard, will draw 28 inches; if of iron she will draw 24 inches, a gain of 4 inches in draught in favor of an iron hull.

To determine whether it will be better to build the new hull of wood or of iron, the following considerations are presented.

It will be seen that the *Ohio* now draws 13 inches more than when built, and the *Oswego* 6 inches more. This is due partly to the fact that a wooden hull becomes water-soaked in time, and partly to its breaking down at the ends. In fact, the hulls of all wooden boats built for the shallow waters of Western rivers show these two faults after a couple of years' service. The *Ohio's* hull has rotted so badly that the seams will no longer hold oakum, and cannot therefore be made water-tight.

Several methods of chaining to keep the hulls in shape have been tried, but with only partial success, and I am satisfied that, for the heavy work required on the Ohio River, it is impossible to build a light-draught wooden hull that can be kept in shape. As soon as the timbers soften, the fastenings begin to give way; and even when new they cannot be made as solid as they should be.

As stated above, a wooden hull well built would draw 4 inches more than an iron one; and whereas an iron hull would not have any apparent increase of draught in say 10 years, the wooden one would, if not worn out, have a draught at least 15 inches greater than when new.

Moreover, an iron hull would from the first be very much stronger than a wooden one, and in case of injury it could readily be put in as good condition as when new, which is impossible with a wooden hull.

As for durability under the usual conditions of service, there is no doubt but that an iron hull would outlast at least three wooden ones.

For these reasons, I think it would be an economy as well as a great gain in efficiency to build the new hull of iron instead of wood, provided it does not cost more than three times as much.

The following is an approximate estimate of cost of both an iron and a wooden hull for the *Ohio:*

DREDGE WITH WOODEN HULL.

Hull ready for machinery	$9,000 00
Capstan-engines, capstans, and spud-hoist	2,000 00
Transfer and repair of machinery	2,000 00
Total	13,000 00

DREDGE WITH IRON HULL.

Hull ready for machinery	$22,000 00
Capstan-engines, capstans, and spud-hoist	2,000 00
Transfer and repair of machinery	2,000 00
Total	26,000 00

The life of a wooden hull well built should be about eight years. Our past experience shows that during this time such a hull would cost for repairs as much as the amount originally paid for it, while the repairs to an iron hull would probably not exceed $2,000 for the same period.

The loss of working time caused by accidents to the wooden hulls as shown by experience averages about $600 per annum. What an iron hull would lose during the same time can only be estimated, but in order not to make the comparison too unfavorable, we will put it at $300, or one-half the loss caused by a wooden hull.

Summing up on the basis of one iron hull and three wooden ones in 24 years, we have:

Three wooden hulls, at $9,000	$27,000 00
Repairs for 24 years	27,000 00
Value of working time lost 24 years, at $600	14,400 00
Cost for 24 years	68,400 00
Cost per annum	2,850 00
One iron hull	$22,000 00
Repairs for 24 years, at $250	6,000 00
Value of working time lost 24 years, at $300	7,200 00
Cost for 24 years	35,200 00
Cost per annum	1,467 00

Under these circumstances, I would strongly advise that the new hull for the *Ohio* be made of iron. This will involve an estimated cost for hull-capstan-engines, capstans, transfer of machinery, &c., of $26,000.

It may be well to add in conclusion, that since the wooden cranes of the two dredges have been replaced by iron cranes, the annual repairs of this part of the dredges has been reduced three-fourths and no working time has been lost through accidents to cranes.

I have the honor, therefore, to submit the following estimate:

ESTIMATE FOR FISCAL YEAR 1879–'80.

To complete movable dam at Davis's Island	$254,593 00
Dikes at Four Mile, Portland, Puppy Creek, and Caseyville	115,500 00
Removal of steamboat wrecks	20,000 00
New hull for dredge Ohio	26,000 00
Running expenses of snag-boat and dredges 8 months, at $6,000	48,000 00
Office expenses and contingences	35,907 00
Total	500,000 00

LITTLE KANAWHA RIVER.—WORK OF THE PRESENT SEASON.

The sum available at the opening of the season was $18,930.69, of which $18,000 was appropriated by the act of June 18, 1878, the balance being left over from the appropriation of 1876. Of this sum, $3,000 has been allotted to continuing the work of removing snags and rocks begun last season, and the remainder to commencing a lock near Burning Springs, W. Va.

ESTIMATE FOR FISCAL YEAR 1879–'80.

The proper work for the ensuing fiscal year will be the completion of the lock and dam near Burning Springs. The location of this work has been definitely fixed, and its estimated cost is as follows:

Masonry lock	$65,000 00
Timber dam	13,000 00
Engineering and contingencies	5,000 00
Lockkeeper's house	1,200 00
Total	84,200 00
Available	15,930 00
To be appropriated	68,270 00

The difference between the above estimate for the lock, and the general estimate on a lock for the Little Kanawha contained in my report of January 9, 1875, arises in part from the fact that I have increased the length of the lock from 143 to 150 feet and the width from 23 to 28 feet. This will better accommodate navigation, the first-named dimensions being those of the locks now in existence which are somewhat too small. The chief difference, however, is due to the fact that no available site could be found with bed-rock extending entirely across the river. At the site chosen we have rock bottom for three-fourths the distance across. The lock has been placed on the side where there is no rock so as to secure the best foundation for the dam. This necessitates increased expense for foundations for the lock, but it is easier to hold the lock upon bad ground than the dam, and this arrangement is therefore the best that can be made.

Respectfully submitted.

WM. E. MERRILL,
Major of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

U 5.

PROTECTION OF THE COMMERCE OF CINCINNATI FROM DAMAGE BY ICE-FLOODS IN THE OHIO RIVER.

UNITED STATES ENGINEER OFFICE,
Cincinnati, Ohio, December 28, 1877.

GENERAL: I have the honor to submit the following report on the best means of protecting the commerce of Cincinnati from damage by ice-floods in the Ohio River. This report is made in accordance with a resolution which passed the House of Representatives March 2, 1877, and which reads as follows:

Resolved, That the Secretary of War be requested to report to Congress on the best methods, by harbors of refuge or otherwise, of protecting the river-commerce of Cincinnati from floes of ice in the Ohio.

HISTORY OF THE ICE-FLOOD OF 1876–'77.

Before discussing details of protection from ice-floods, it seems proper to give a history of the break-up of last winter, which was an unusually destructive one, and was doubtless the direct cause of the passage of the resolution in question, and also of two previous resolutions on the same subject, which will be mentioned further on in the report.

The first obstruction by ice during the winter of 1876–'77 occurred on the 8th of December, on which day the thermometer fell from 34 degrees at 4 p. m. to zero at midnight, notwithstanding which a few steamboats left port. On Saturday, the 9th, the weather continued cold, and the ice became so heavy that the underwriters would assume no further risks, and ordered all boats into winter-quarters. During the next week a few trips were made between Cincinnati and Huntington, but, owing to ice-gorges below Cincinnati, only one or two boats left for the South, and none of them succeeded in getting through to Louisville. A second spell of very cold weather began on the 16th of December, and entirely suspended navigation for the whole length of the river.

At the Cincinnati Southern Railway bridge, which crosses the Ohio near the lower end of the city, the Keystone Bridge Company had just completed the scaffolding for the main-channel span, and had notified the public that this space was closed to navigation by an advertisement dated December 9, the very day that the cold wave arrived. It was on this day, also, that a strong upstream wind dislodged some of the floating booms thrown out to protect the trestling, and left it unsupported to resist the whole weight of moving ice. As this trestling obstructed a width of upward of 500 feet in the middle of the river, it was to be expected that the ice would first gorge here. The gorge occurred at noon of the 11th, and at 4.45 p. m. had become so heavy that the trestle-work gave way, and all of the bents except one or two on the north side were carried off. No iron-work of the superstructure had been put in place, and therefore the loss was confined to the timber false-works; it was estimated at $10,000, not including the damage caused by the delay in the completion of the bridge. The formation and movement of this gorge sunk several coal-barges, and occasioned a loss of $5,000 at the coal-landings between Central avenue and the site of the bridge. No other damage was reported in the vicinity of Cincinnati while the river was closing up. Some losses were sustained at points above and below the city, but in all cases they were quite small.

The weather continued cold, and the river remained low, so that on

the 26th of December pedestrians and teams were crossing the Ohio on the ice, not only at Cincinnati, but as far south as Evansville. The characteristic feature of the winter was a month of continued low temperature from December 9 to about January 9, giving on the Ohio itself a bountiful crop of clear ice, which in some places was said to average 14 inches in thickness.

There are no safe ice-harbors at or near Cincinnati, and most of the steamboats in port were, as usual, crowded along the public landing, between the Newport ferry and the suspension bridge. The danger to these boats from any movement of ice was early apparent, for they were so tightly frozen in that any movement of the ice-field would have inevitably carried them along with it. In order to release them from the main body of ice, the underwriters, at an expense of $250, cut a channel, just outside the boats, from the foot of Central avenue up to the foot of Sycamore street, which was afterward continued by the Pomeroy Packet Company up to the Newport Ferry Landing, thus leaving a narrow strip of open water outside of all the boats at the landing, and disengaging them from the main ice-field. This work was completed by the 29th of December, and the strong current kept the channel open for the rest of the winter.

Meanwhile, in the lower part of the harbor, the Fifth-street ferry-boat and the tow-boat Kate Waters had kept open the line of the ferry and a space extending upstream several hundred feet.

On the 5th of January a narrow channel was cut by hand from the wharf-boat of the Louisville Mail Line immediately below the suspension bridge across to the coal-landing on the Kentucky shore. During the next day the field of ice below this cut and above the foot of Fifth street moved down some 300 feet and then held fast on the point opposite Mueller's stone-yard, without doing any particular damage. This movement left a small section of open river below the suspension bridge, and contracted, but did not close, the opening near the foot of Fifth street. Taking advantage of the new situation, one of the Champion tow-boats, which lay in the mouth of the Licking, attempted to clear out the channel above the suspension bridge and opposite the public landing. The ice, however, proved so heavy, that she succeeded in getting only a short distance from the shore, and accomplished no useful result.

The cold term was followed by heavy rains on the northwestern slope of the Allegheny Mountains, which raised all the streams coming in from West Virginia and Kentucky, and caused a rise in the Ohio that forced out the heavy ice before it had begun to weaken. A break-up under such conditions is, of course, much more dangerous to property than one occurring after the ice has become gradually rotted by mild weather, and is, therefore, too soft to do any injury when put in motion. It is a rare thing for ice to attain such strength as it did last winter, and it is very seldom put in motion by so great a flood. The conditions were, therefore, favorable for heavy losses.

The rise that started the ice began in the bend of the Ohio near the mouths of the Kanawha and Big Sandy, and it gradually forced its way southward, the ice at each point holding the flood back until broken up by its irresistible pressure. On the 9th of January there was a movement at Ironton and Portsmouth, which sunk and carried away coal-boats and did much damage. The first serious movement at Cincinnati took place on the 12th. At Louisville it began on the 14th, at Evansville on the 15th, and at Shawneetown on the 16th. While this was going on in the Middle and Lower Ohio, a similar disastrous flood was pouring down the Monongahela and its tributary, the Youghiogheny.

[illegible]

The movement of the ice commenced at 7 a. m. of Friday, January 12, when the ice-field in front of the public landing broke away from the Newport and Covington bridge, and moved down 50 feet, carrying up the opening below the suspension bridge, and sinking the steamer Cabinet, which lay at the head of the line of boats extending in close contact from Lawrence street to Vine. The barometer marked 29.6 inches, and every portage to the channel was outside of the cradle for their protection. The heavy field ice suddenly moved down and the Cabinet, close to which I was standing, the first report that reached my ears. After moving a few hundred feet she was checked by that below and the movement stopped. At 11 p. m. on the same evening a second movement of the ice-field occurred, which sank the steamer Ariel, lying at the foot of Main street. Both the Cabinet and the Ariel were sunk by the ice that formed in the harbor before it had moved a thousand feet. An early effort was made by the Champion No. 3 to cut her way across from Licking to pump out and raise the Cabinet, but the ice was so heavy that she was unable to break through it. On Sunday morning, January 14, the river was open directly in front of the city, but gorged above at the marine ways and below at Cullom's. At 11.40 a. m. these gorges broke, and as the river was rising rapidly, no new gorge could form, and no further damage occurred. Navigation was resumed on the 18th of January, after an ice-blockade of forty days.

Besides the steamboats at the public landing and immediately below the suspension bridge, there were four at the mouth of the Licking and five along the right bank below the marine railway and under the lee of the floating ice-breaker thrown out to protect the dry-docks. All of these boats escaped injury. The total number of steamboats in port, including three on the ways at Covington, was 37; of these, 7 were sunk or carried away, 3 of them, however, being small pleasure-boats or steam-launches, valued at $1,000 each.

The amount of coal afloat was 220 barges, of which 8 were partly unloaded. There were also held in port 407 empty coal-barges, which were distributed along both shores from the mouth of the Little Miami to

Sedamsville, and were tied up in fleets wherever there was any hope of protection from the ice.

Owing to the want of a tow-boat that could break through the harbor-ice, many of the empty barges were necessarily left in places where there was small probability that they could escape in case of a bad break-up. The heaviest fleets of loaded barges were at Coal Haven (a point on the left bank of the river nearly opposite the mouth of the Little Miami), at the Queen City elevator, and on the left shore at Ludlow, below the Southern Railway bridge. The greatest loss occurred at Waters's Landing, the lowest landing at Coal Haven. The number of loaded coal-barges lost was 71; the number of empty barges cut down or carried away was 175.

The loss on steamboats and wharf-boats at Cincinnati amounted to $73,650, and that on coal, coal-barges, coal-flats and floats to $202,895; making a total loss of $276,545. These figures have been obtained by personal investigation into each loss, and are believed to be substantially correct. Besides getting the actual value of property lost, I have had both sides of the river from the Little Miami to Sedamsville carefully canvassed to ascertain the number and position of boats at each landing when the ice moved, and which of them were sunk or carried away. Several months, however, had elapsed since the ice-flood, and there was much difficulty in getting the facts required. Discrepancies between the statements made by the owners of coal and by the foremen in charge of the fleets could not always be reconciled, but the results obtained are thought to be quite accurate in the majority of cases, and approximately correct in the others.

Accompanying this report is a map of the harbor of Cincinnati, which shows the position and kind of each boat in the harbor on the 12th day of January, when the ice commenced moving. To make the information embodied in this map more apparent to the eye, all steamboats and barges that were sunk or carried away are colored red; loaded barges are shaded in black; empty ones are indicated only in outline.

Some barges that were carried away were recovered uninjured, but it was quite impossible to ascertain whence they started, and therefore no attempt has been made on the map to distinguish between those that were totally destroyed and those that were carried away and afterward recovered. Numbers of the latter floated out into the Mississippi before they were captured, and the expense of salvage and of bringing back such barges was quite heavy.

The information contained in the map is consolidated in the following table, the total loss sustained at each landing being summed up. Owners of coal-barges could often give their total loss of empty barges, but could not indicate the landings at which they lay; on the other hand, owners of landings could tell the number of barges carried away, but oftentimes did not know how many of them were recovered. The loss in empty barges, therefore, although nearly correct in the aggregate, has probably some errors in detail which could not be avoided.

Table of coal-barges, coal-flats, and similar craft in the harbor of Cincinnati during the ice-blockade of 1876–'77, giving the landings at which they lay, and the number and value of those cut down or carried away at the breaking up of the ice.

Bank.	Name of landing.	AT LANDING.					LOST.					Estimated loss.
		Coal-barges.			Flats, &c.		Coal-barges.			Flats, &c.		
		Loaded.	Partly unloaded.	Empty.	Loaded.	Empty.	Loaded.	Partly unloaded.	Empty.	Loaded.	Empty.	
Left	Brown's, upper	17					3					$5,850
Do	Stewart's	24		22			3		4			7,375
Do	Brown's, lower	13		7	1		1					1,470
Do	Waters's	36		9			26		4			45,000
Right	Kellogg's	7	2		1	4	7	2		1	4	12,500
Do	Yungbluth's	4		3		2	4		3		1	7,000
Left	Trapp & Heeg's			3								
Right	Queen City Elevator	34	1	12		4	3	1	4		4	16,000
Do	Gardner's	1		4		1						
Left	Wolf's Rolling-Mill		2			1		2				1,500
Right	Keystone Elevator			9		2			3		1	500
Do	Dodsworth's	3		6		3						300
Left	Williamson's			1		1			1			
Do	Gordon's			1		1			1		1	250
Do	Newport Barracks			5								
Do	Licking River	9		48	1	23	1		6	1		2,000
Do	Shinkle's	5		10		2	1		4			3,700
Do	Kuntzler's	1		1		1						
Right	Foot of Race street					2						
Left	D. Buchanan's	5		3		3	1		2			2,000
Right	Stevens's			1								
Do	Johnston's	4		3		1			3		1	1,000
Do	Levy's		2	4		2						
Left	Covington Saw-Mill			2								
Right	Marmet's			2		5			2		1	500
Do	Ohio River Salt Company's					1						
Do	Cochnower's, upper			4		2						
Left	Montgomery's			11		3			4			1,000
Right	Buchanan's			3		3						
Left	Covington Docks	1		16		1	1		4			1,000
Right	Gas Company's			8		2			8			7,000
Left	Bateman's	4		9			4		9			16,000
Do	Frenchman's					1					1	100
Right	Rolling-Mill			7		2			7		1	3,000
Do	Mueller's					6						
Do	Phillips's			6		3						
Do	Serena & Stone			4		3						
Do	Bard's	2	1	4		3		1				1,200
Do	Collier, Budd & Co			3		2			3			500
Do	Cincinnati Coal and Coke Company	1	3	10		3	1	3	10		2	5,000
Do	Ross's			2		3						
Do	Fifth Street			2		3			2			1,000
Left	McCoy's			32					32			15,000
Right	Cochnower's, lower		1	7		4		1	7		2	5,000
Do	Zimmerman's			6		3			5			4,000
Do	Keck's					3					3	3,000
Do	Buckeye	1		2		1	1		1			1,150
Do	Mill Creek			5								
Do	Gaff's					1						
Left	Walmer's	3		38								
Do	Keystone					3						
Right	Flemming's	5		7	4	1	4		5	3		9,000
Do	Twenty-first Ward			6		2			6			1,300
Left	Walmer & Peckleheimer			22					10			2,000
Do	Crail & Wall	30		27	3	1	4		23	3	1	15,000
Right	Boldface			4		7					6	500
	Total	210	12	401	10	125	65	10	173	8	29	202,805

List of steamboats, wharf-boats, and model barges in port, showing their position and the loss from ice.

Name of boat.	Position.	Estimated loss.	Remarks.
Wildwood	Cincinnati dry-docks		
Exchange	Cincinnati marine ways		
Warner and two model barges	Foot of Bird street		
Laura L. Davis	Litherbury's		
Lily	do		United States light-house tender.
Hiram Watson	Gardner's		
Millie Roberts	N. and C. Bridge, Newport		Small boat, slightly damaged.
Newport Belle and Float	Newport and Cincinnati Ferry Landings.		Ferry-boat.
Cincinnati Belle and Float			Do.
Calumet	Between Lawrence street and the suspension bridge.	$30,000 00	
Vint Shinkle			
Golden City			
Telegraph			
Bostona			
Bonanza			
Big Sandy, wharf-boat		2,000 00	Damaged.
New Orleans, wharf-boat			
Andy Baum			
Andes		20,000 00	Sunk.
Mary Miller			
Emma Graham			
Shinkle's wharf-boat			
Champion No. 7	Mouth of Licking		
Champion No. 8	do		
Champion No. 9	do		
Ben Franklin	do		
Seven model barges	Up the Licking	50 00	One slightly damaged.
Louisville Mail-Line wharf-boat	Below suspension bridge, Cincinnati.		
United States	do		
General Buell	Below suspension bridge, Covington.		
Robert Peebles	Foot of Race street	350 00	Slightly damaged.
Central avenue ferry-boat and two floats.	Foot of Central avenue		Ferry-boat.
Hull of Nick Longworth	Sampson's Landing	50 00	A dismantled hull.
Kate Waters	On Covington docks		
Mark Twain	do		
Business	do		
Mocking Bird	Collier, Budd & Co.'s	2,000 00	Propeller, sunk.
Fanny Webster and three floats	Ludlow Ferry Landing	5,000 00	Boat and two floats destroyed.
Minnie Keenan	McCoy's Landing		Carried away and recovered.
Naomi	Ludlow	700 00	Destroyed.
Water Lily	do	500 00	Do.
Water Witch	Mill Creek	500 00	Do.
One model barge	Flemming's		
Liberty, and four model barges	Sedamsville	12,000 00	Loss of two model barges, loaded with salt and fire-brick.

SUMMARY.

Class.	In port.	Destroyed or damaged.	Estimated loss.
Freight and passenger steamboats	15	2	$50,000
Tow-boats	8	1	350
Ferry-boats	4	1	3,500
Small tugs and pleasure-boats	8	5	3,700
Model barges	14	3	12,550
Dismantled hull	1		
Wharf-boats and ferry-floats	12	4	3,550
United States light-house tender	1		
Total			73,650

HARBOR-ROOM REQUIRED.

As it is manifestly impossible to determine what will be the future amount of the commerce of Cincinnati, it will be assumed that harbor-room sufficient to provide for the craft that were actually in port on the 12th day of January, 1877, will answer the purpose of this report.

A coal-barge may be taken as measuring 130 by 24 feet, or 3,120 square feet. The net area of the harbor-room required for 623 coal-barges will therefore be 1,943,760 square feet, or 44.6 acres. If to this we add 10 per cent. as the least possible allowance for waste room and passage-ways, we shall have 49 acres as the harbor-room required to contain all the coal-barges that were in Cincinnati last winter.

The net area required to contain 135 flats, floats, and miscellaneous craft will be 270,000 square feet, or 6.0 acres; which increased by 10 per cent. becomes 6.8 acres. This added to the 49 acres previously found gives 55.8 acres as the area required to contain the water-craft included in our first table.

In getting the area required for steamboats we may omit all ferry-boats, wharf-boats, dismantled hulls, and diminutive steamboats of all kinds, thus reducing the number to be provided for to 24 steamboats (including tow-boats) and 14 model barges. Each steamboat may be assumed to require an area of 12,000 square feet, and each model barge an area of 4,500 square feet. For 24 steamboats there would therefore be required a net area of 288,000 square feet, or 6.6 acres; and for 14 model barges a net area of 6,300 square feet, or 1.5 acres; adding 10 per cent., as before, we find that the steamboats will require 7.3 acres, and the model barges 1.7 acres.

Collecting the areas found above, we have:

	Acres.
Area necessary for 623 coal-barges	49.0
Area necessary for 135 flats, floats, &c	6.8
Area necessary for 24 steamboats	7.3
Area necessary for 14 model barges	1.7
Total	64.8

It is thus shown that a water-surface of 64.8 acres, or in round numbers 65 acres, would be required to accommodate the winter commerce of Cincinnati.

AVAILABLE HARBORS.

The only harbors, properly so called, that can be made on a river like the Ohio are such as can be excavated out of its banks. The large tributaries are generally as dangerous as the main river, and the only resource is to dig into the shores, wherever there are low areas that will reduce the cost of excavation. The valleys of the creeks and small streams are naturally the only places where such areas can be found.

It is essential to the usefulness of a harbor that boats should always be able to get into it during the proper season.

The harbors herein discussed are solely designed for protection from ice-floods, as floods unaccompanied by ice are not dangerous.

The ordinary demands of commerce require that steamboats and barges be at their usual landings as long as possible. Steamboats can transact their regular business until the very day the river closes, as they have the ability to propel themselves to any desired point at a few hours' notice, and even to force themselves through thin ice. A considerable amount of time would, however, be required to lay up barges for the winter.

It is thought that at least one month would be necessary for the transfer to the harbors of refuge of all the barges that are intended to be sheltered there, if the movement is to take place without confusion or vexatious delays.

The month in question would evidently be the month immediately preceding the closing of navigation. To ascertain at what date this may be expected the files of the Cincinnati Commercial have been carefully examined, and the following table giving the dates and duration of the stoppage of navigation at Cincinnati during the last twenty years, has been compiled therefrom:

Winter.	Navigation suspended by running ice.	River entirely closed.	River open and navigation resumed.	Remarks.
1857–'58	.....	.....	.....	No serious interruption.
1858–'59	.....	.....	.....	No serious interruption; river high.
1859–'60	Jan. 2	.....	Jan. 10	
1860–'61	.....	.....	.....	No serious interruption.
1861–'62	.....	.....	.....	Do.
1862–'63	.....	.....	.....	No serious interruption; river high.
1863–'64	Jan. 4	Jan. 17	Jan. 25	
	Feb. 19	.....	Feb. 23	
1864–'65	Jan. 30	.....	Feb. 6	
1865–'66	Feb. 15	.....	Feb. 20	
1866–'67	Dec. 30	.....	Feb. 5	Occasional trips could be made.
1867–'68	Jan. 19	.....	Jan. 23	
	Jan. 31	.....	Feb. 15	Do.
1868–'69	.....	.....	.....	No serious interruption.
1869–'70	.....	.....	.....	No serious interruption; river high.
1870–'71	Dec. 24	.....	Jan. 14	
1871–'72	Dec. 19	Dec. 21	Dec. 24	
	Dec. 28	Dec. 29	Dec. 31	
	Jan. 9	Jan. 10	Jan. 12	
	Jan. 27	Jan. 30	Feb. 20	
1872–'73	Dec. 13	Dec. 23	Jan. 4	Heavy ice running until February 6.
1873–'74	.....	.....	.....	No serious interruption.
1874–'75	Jan. 12	Jan. 21	Jan. 30	
1875–'76	.....	.....	.....	No serious interruption; river high.
1876–'77	Dec. 9	Dec. 19	Jan. 18	Ice began moving out January 13.

It will be seen from the above that during nine years out of the twenty examined, or during 45 per cent. of the winters, there was no stoppage of navigation by reason of ice. The earliest stoppage during the period in question was that of last winter (1876–'77), which began on the 9th of December. The next earliest was in the winter of 1872–'73, which began on the 13th of December. If, therefore, we make our harbors accessible on and after November 10, there will always be at least one month for barges to enter them.

Coal-barges usually draw 6½ feet, and ought to lie in at least 7 feet depth of water to prevent grounding. It is therefore evident that the conditions of the problem require that the proposed harbors of refuge shall have at least 7 feet of water from the 10th of November to the end of freezing weather.

An inspection of the gauge-records kept at this city since June, 1858, shows that the river is always higher in the latter part of the winter than in November and December.

The following table shows the dates, since 1858, at which the river has stood at less than 7 feet on the Cincinnati gauge between the 10th

of November and the 31st of December, together with the corresponding gauge-readings:

		′	″
	1858.		
Nov.	23	6	9
	24	6	6
	25	6	4
	26	6	2
	27	6	0
	28	6	10
	29	7	7
	1859.		
Nov.	10	4	9
	11	4	9
	12	5	0
	13	10	0
	14	7	4
	15	6	0
	16	8	2
	1862.		
Nov.	10	5	1
	11	5	1
	12	4	0
	13	4	9
	14	4	7
	15	4	6
	16	4	5
	17	4	4
	18	4	3
	19	4	3
	20	4	1
	21	5	2
	22	4	4
	23	4	0
	24	3	11
	25	3	11
	26	3	11
	27	7	0
	28	12	6
Dec.	14	6	4
	15	5	10
	16	6	9
	17	7	3
	18	6	3
	19	5	9
	20	5	7
	21	6	1
	22	8	9
	1863.		
Nov.	10	6	8
	11	6	9
	12	6	8
	13	6	11
	14	7	0
	15	6	11
	16	6	8
	17	6	7
	18	6	7
	19	6	7
	20	6	7
	1863.		
Nov.	21	6	10
	1867.		
Nov.	14	6	11
	15	6	10
	16	6	8
	17	6	4
	18	6	1
	19	5	8
	20	5	5
	21	5	2
	22	4	11
	23	4	10
	24	4	8
	25	4	7
	26	4	5
	27	4	3
	28	4	3
	29	4	2
	30	4	3
Dec.	1	4	5
	2	4	5
	3	4	2
	4	4	0
	5	4	1
	6	4	3
	7	4	5
	8	4	9
	9	5	6
	10	6	3
	11	6	7
	12	7	2
	1869.		
Nov.	10	6	4
	11	6	2
	12	5	11
	13	5	8
	14	5	7
	15	5	5
	16	5	5
	17	6	0
	18	6	1
	19	6	5
	20	6	7
	21	6	10
	22	7	3
	1871.		
Nov.	10	4	11
	11	4	7
	12	4	5
	13	4	3
	14	4	4
	15	4	8
	16	4	9
	17	4	8
	18	4	5
	19	4	3
	1871.		
Nov.	20	4	5
	21	9	9
Dec.	10	6	5
	11	5	10
	12	5	6
	13	5	5
	14	5	4
	15	5	2
	16	5	1
	17	4	11
	18	5	0
	19	5	0
	20	5	2
	21	6	9
	22	5	11
	23	5	11
	24	7	1
	25	7	0
	26	6	10
	27	6	9
	28	6	9
	29	8	8
	1877.		
Nov.	27	6	8
	28	6	3
	29	5	11
	30	5	11
Dec.	1	5	11
	2	6	5
	3	6	7
	4	6	7
	5	6	4
	6	6	0
	7	6	0
	8	6	9
	9	8	4
	1874.		
Nov.	10	3	0
	11	3	0
	12	2	11
	13	2	10
	14	2	11
	15	3	0
	16	2	11
	17	3	0
	18	3	1
	19	3	3
	20	3	7
	21	3	5
	22	3	4
	23	4	3
	24	4	10
	25	4	11
	26	4	10
	27	8	7

The above table shows that the lowest water during the period under examination was in November, 1874, and that the lowest reading was 2 feet 10 inches on the gauge. The next lowest water during the same period occurred in November, 1862, and read 3 feet 11 inches on the gauge. There was no serious interruption from ice during the winter of 1862–'63, and in the winter of 1874–'75 the river did not close until January 12; but these conditions could not have been foreseen, and we may therefore still assume that had ice-harbors been available, coal-barges would have been in them at the times of these lowest stages. To have kept these barges from grounding in the worst of the two seasons, the bottom of the harbors should be 7 feet below the lowest gauge-reading given above—or, in other words, they should be 4 feet 2 inches below the zero of the gauge. It will suffice, however, to put them at an even

4 feet below this level, and this depth has, therefore, been taken for the excavation of the proposed harbors of refuge.

In order to avoid as much as possible the construction of masonry, it is assumed in the estimates that the sides of the basins will be paved slopes instead of retaining-walls. For the same reason, the entrances have been considered as having paved slopes, although masonry walls would undoubtedly be much better for this purpose.

Several localities for harbors, otherwise desirable, are unavailable because they are on the convex bank of the river—in other words, because they are on the side where the tendency of the currents is to cause deposits and make sand bars. Occasional dredging will probably be necessary in order to keep open the mouth of any recessed harbor, even though made on a favorable shore, unless a scour can be established through it by means of a large and continuous supply of water entering the basin from the land behind. It would be hopeless to attempt to keep open the mouth of a harbor which is both on the convex bank and is without an independent supply of water. A harbor that would probably give continuous occupation to one or more dredges had better not be attempted.

MOUTH OF THE LITTLE MIAMI.

A harbor with an area of 31 acres has been surveyed on the right bank of the Ohio and the right bank of the Little Miami, at the mouth of the latter. Such a harbor is indicated on sheet A, the general map of the harbor of Cincinnati, and is also shown in detail on sheet No. 2. A much larger area than 31 acres can be obtained here if desired, but the survey only included this amount, and as there are some strong objections to a harbor at this locality, it has been thought best to prepare the estimate on the area actually surveyed. The whole estimated space of 65 acres can be obtained here without difficulty.

The design is to excavate in the lower angle between the Miami and the Ohio, using the excavating material to protect the excavation from floods in either river. In order to obtain the necessary water-supply, with sufficient current to keep open the outlet of this harbor, it would probably be necessary to build a dam across the Miami and provide it with sluices leading into the basin. The outlet would lead directly into the Ohio, as is shown in map No. 2.

In this part of the Ohio the strongest current is along the left shore, the current along the right shore being comparatively slack. The Little Miami has across its mouth a bar of sand and gravel that is almost dry in low-water. It may therefore be considered as certain that an entrance into the harbor through the mouth of this river would require a large amount of dredging each year to keep it open at all stages of water.

The amount of excavation to make a basin of the area of 31 acres would be 2,318,800 cubic yards, which, at 30 cents per cubic yard, would amount to $695,640.

The average depth of the excavation would be 41.1 feet. The surface to be paved would be 53,745 square yards, which, at $1 per square yard, would amount to $53,745.

The cost of building a dam across the Little Miami and constructing proper sluices into the basin would amount to about $60,000.

It must be borne in mind that in order to procure 31 acres of harbor-room at low-water it will be necessary to purchase enough additional land to provide for the sloping sides of the basin. In the case in hand this additional land amounts to 15 acres, thus compelling the purchase

of 46 acres to secure a low-water harbor of 31 acres. At an assumed price of $100 per acre this land will cost $4,600.

The total cost of a harbor of refuge at this point, having an area of 31 acres, would therefore be $813,983, which is at the rate of $26,258 per acre of harbor-room.

CRAWFISH CREEK.

The next point examined is at the mouth of Crawfish Creek, between the railroad and the river. The area surveyed is shown on the general map, and the details of the ground on sheet No. 1.

This harbor is favorably situated for access at all stages, as its outlet is through a concave bank, passing directly into the deep water that is always found near such banks. There is no tendency to deposit along the shore near the mouth of Crawfish Creek, and the only dredging that would probably be required at this harbor would be the removal of the small deposits that would work into the entrance from the slight eddy that would naturally form there.

In calculating the amount of excavation at this locality, and the available area for shipping, it was thought best not to pass beyond the bounds of the natural depression, as any digging into land whose surface is on a level with the river-bank would be exceedingly expensive without adequate result. With due allowance for side slopes, this natural basin gives an available harbor-area of 13 acres. The nature of the material to be excavated was determined by boring through it to a depth of 4 feet below low-water. As shown on the map, the hole was sunk in the bed of the creek nearest to the base of the hills, where it was thought most likely that rock would be found. No rock was found, however, and the material for the whole depth proved to be fine gravel and sand. The same kind of material probably prevails throughout the whole area of the basin.

The amount of excavation required for the harbor proposed would be 922,000 cubic yards, which, at 30 cents per cubic yard, would cost $276,600. The average depth of excavation would be 40.9 feet. The amount of paving would be 32,700 square yards, which, at $1 per square yard, would cost $32,700. The land required would cost, as far as I can learn, about $700 per acre; 19 acres will be required, and the cost of the tract would therefore be $13,300.

The total cost of a harbor at this locality would therefore be $322,600, or an average of $24,815 per acre of harbor-room.

Should this part of the city become thickly populated it might then be necessary to cross the outlet of the harbor by a draw-bridge, but as this is not a present necessity no allowance has been made for it in the estimates.

MILL OR TAYLOR'S BOTTOM.

The next point to be considered as we descend the river is Mill or Taylor's Bottom, which lies along Taylor's Creek, between the towns of Newport and Bellevue in Kentucky.

A report on the proposition to make a harbor at this locality was made by me on the 5th of February, in response to a resolution of the House of Representatives, dated January 30, 1877. This report is printed as Ex. Doc. No. 39, Senate, Forty-fourth Congress, second session.

The chief obstacle to utilizing Taylor's Creek Bottom for a harbor of refuge is the sand bar that lies across its mouth, and which in low-water is dry to within one square of the Newport and Cincinnati bridge. This is the natural sand bar of a convex shore, and there is no way of keep-

ing open a channel through such a bar, except by constant dredging or the continual scour of a large volume of water issuing from the mouth of the creek. As the latter is usually very nearly dry in summer and fall, it was manifest that the natural conditions at this locality were an insuperable barrier to the creation of a practicable harbor, and therefore no detailed survey was made.

MOUTH OF THE LICKING.

The Licking River itself is much used as a harbor of refuge, but it is considered a hazardous one, as this stream is subject to rapid rises that make it unsafe even in summer. In obedience to the act of Congress, approved March 3, 1871, I made a survey of the mouth of the Licking as a harbor of refuge, and my report was printed in Ex. Doc. No. 252, House of Representatives, Forty-second Congress, second session. It was also reprinted in the Annual Report of the Chief of Engineers for 1872, pp. 420–425, and I would refer to these documents for further information, merely stating that the largest lateral harbor that could well be made near the mouth of the Licking was estimated to give an available area of 9.8 acres, and that its least cost was estimated at $741,000, of which $167,000 was the cost of excavating a channel through the wide rock bar that now obstructs the mouth of this river.

WILLOW RUN.

The next point that requires investigation is the basin of Willow Run, a small stream on the Kentucky side that enters the Ohio at the lower or western edge of the city of Covington. This location has the advantage of deep water at the mouth of the creek, and of being nearly opposite the center of Cincinnati. The detailed survey of this tract is shown on sheet No. 3.

The area of the basin laid out in this bottom is 19.3 acres. The width of the entrance is taken at 100 feet, except at the crossing of Third street. Here a draw-bridge would evidently be required, and in order to avoid having so great a weight as to require the use of steam for turning it, the width of clear opening has been placed at 60 feet.

The average depth of excavation is 46.4 feet, and the total amount to be excavated is 1,553,000 cubic yards. This, at 30 cents per cubic yard, would cost $465,900. The total surface to be paved is 50,700 square yards, which, at $1 per square yard, amounts to $50,700. The cost of the draw-bridge at Third street, with its abutments and pivot-piers, would be about $45,000. The cost of the ground is an uncertain item, as none of it is utilized at present, and its future value depends entirely upon the growth of the city of Covington. But some price would have to be paid for land if a harbor of refuge were made in this locality, and therefore I have placed it at $2,000 per acre, which is about the average price put upon it by real-estate dealers in Covington. As 27 acres would be required in order to secure 19.3 acres of harbor-room at low water, the total cost of the land would be $54,000.

Adding these items we find that the cost of this harbor would be $615,600 for 19.3 acres, or at the rate of $31,900 per acre of harbor-room.

The estimate is based on the supposition that no rock will be found in excavating to the required depth. Two test-borings (positions indicated on the map) were made to a depth of 4 feet below low-water level without encountering any other material than alluvial deposits of gravel, sand, and clay.

MILL CREEK.

The next available point is the valley of Mill Creek, an Ohio stream that enters the river in the lower part of Cincinnati. Both banks of this stream, within 5 miles of its mouth, are within the corporate limits of Cincinnati.

A resolution of the House of Representatives, dated January 17, 1877, called for a special report on the expediency and utility of constructing a harbor of refuge at this point. By direction of the Chief of Engineers, I made such a report, and it was printed as Ex. Doc. No. 34, House of Representatives, Forty-fourth Congress, second session. I would respectfully refer to that document for my reasons for considering a harbor of refuge in Mill Creek bottom as impracticable. As a careful examination of this project, made subsequent to the report in question, failed to develop any new points in its favor, no special surveys have been made in this bottom. The location is indicated on the general map.

PLEASANT RUN, BROMLEY.

This was the lowest locality examined. Pleasant Run is a small stream that enters the Ohio from the Kentucky shore at a point one and a half miles below the Cincinnati Southern Railway bridge. The point on the Kentucky shore immediately opposite the lower boundary-line of Cincinnati is 1,500 feet below the mouth of Pleasant Run.

The available low-water area for a harbor in the valley of this stream is 30.3 acres. The low area is some distance back from the river, and is reached by an entrance 60 feet in width. The average depth of excavation is 40.8 feet, and the total amount is 2,031,000 cubic yards, which, at an average price of 30 cents per cubic yard, would cost $609,300. The surface to be paved is 45,000 square yards, which, at $1 per square yard, will cost $45,000. As the mouth of the run is now crossed by a fixed bridge, this would have to be replaced by a draw-bridge. With the usual openings of 60 feet, such a bridge would cost, including masonry and piers, about $45,000.

Two test-borings were made to determine the nature of the excavation required. Their position and the particular nature of the materials found are shown on the special map of the site, which is marked sheet No. 4. Both holes were sunk to 4 feet below ordinary low water, and they show that, to the depth required, this basin, like the others, contains mainly an alluvial deposit of sand, clay, and fine gravel. The soft clay-stone exposed in the bed of the creek on the south side of the basin limits the harbor on that side. It is believed that due allowance has been made for this rock, although the funds allotted for the work would not permit sufficient borings to determine its exact position.

This harbor, like that at the mouth of the Little Miami, opens on a shore where the current is not strong, and where deposits are likely to appear if the present regimen is changed, either by excavating an outlet or by building dikes. It is therefore probable that the entrance to this harbor would have to be kept open by constant dredging.

The value of the land is, as usual, indeterminate; but the best information puts its present price at $50 per acre, and as 41 acres would be required, its cost would be $2,050.

The total cost of this harbor would, therefore, be $701,350, which is at the rate of $23,147 per acre of harbor-room.

SUMMARY.

Summing up in tabular form the results that have been determined above, we have—

	Little Miami.	Crawfish.	Willow Run.	Pleasant Run.
Average depth of excavation.....feet..	41.1	40.9	46.4	40.8
Amount to be excavated.....cubic yards..	2,318,800	922,000	1,553,000	2,031,000
Cost of excavation	$695,640	$276,600	$465,900	$609,300
Surface to be paved .....square yards..	53,745	32,700	50,700	45,000
Cost of paving	$53,745	$32,700	$50,700	$45,000
Cost of dam and sluices	60,000	.....	.....	.....
Cost of bridges.....	.....	.....	45,000	45,000
Cost of land	4,600	13,300	54,000	2,050
Total cost of harbor.....	813,985	322,600	615,600	701,350
Available area .....acres..	31	13	19.3	30.3
Cost per acre of harbor.....	$26,258	$24,820	$31,900	$23,147

It is proper to repeat that there is no difficulty in obtaining as much harbor-room as may be needed at the mouth of the Little Miami, although the survey only embraced 31 acres, and that an increase in the area of harbor would reduce the cost per acre by apportioning the cost of the entrance and of the sluices among a greater number of acres.

On account of the difficulty of keeping open their entrances, it is thought that neither the mouth of the Little Miami nor Pleasant Run is available as a site for a harbor of refuge. Of the four sites to which our choice is practically limited, the two just named have the additional disadvantage of having the most inconvenient locations, the former being above the upper boundary of the city, and 7 miles above the suspension-bridge (which is practically the middle point of the harbor of Cincinnati), and the latter about opposite the lower end of the city. The distance between the outlets of these two projected harbors is therefore 10¼ miles, the length of river between the corporate limits of Cincinnati being 9 miles.

The only sites in this vicinity that are at all practicable are Crawfish Creek and Willow Run, both of which combined would only give a harbor-room of 32.3 acres, instead of the 65 acres which our preliminary calculation showed to be necessary for the complete protection of the shipping of Cincinnati. We may, therefore, sum up by stating that our investigations have developed the fact that one-half the shipping of Cincinnati could be sheltered in harbors of refuge at a cost of $940,000. The locations of these two harbors are very good. Crawfish ice-harbor, 4½ miles above the suspension-bridge, would be of convenient access to the boats that frequent the upper part of the harbor of Cincinnati, and Willow Run, three-quarters of a mile below the suspension-bridge, would accommodate the central and lower parts of the harbor.

After consultation with persons interested in the river commerce of Cincinnati, I have come to the conclusion that it is unnecessary to provide for more than one-half of this commerce, as the majority of the steamboats will remain at their landings until the river closes, trusting that the detention will be slight, or that, if it should be long, they will escape injury, as the greater number always do escape. As far as the steamboat interest is concerned, harbors of refuge are only needed for steamboats that are not in commission when the river closes, and for the few others that may be able to reach these harbors after the river has frozen up. An allowance of one-half the calculated area will therefore probably suffice for the steamboat interest.

The chief reason why the coal interests desire a harbor of refuge is that they may obtain secure shelter for their reserve supply, the greater part of which is now stored above and below the harbor proper. But even with harbors of refuge, the majority of coal-owners would always keep a large number of barges at their landings all winter in order to meet the ordinary demands of consumers. For this reason, I think that one-half of the estimated harbor-room would suffice for the coal interest. It follows from the above that the projected harbors at Crawfish Creek and Willow Run would probably suffice to contain all the boats that would use them if constructed.

OTHER METHODS OF PROTECTION.

This report would not be complete were it to omit to mention other methods of protection for boats that cannot or will not leave their landings and enter an artificial ice-harbor.

Ice-breakers.—In the pools of the Monongahela, where many coal-boats and barges are harbored, protection from ice is secured by ice-breakers. These are usually spur-dikes, projecting at right angles from the bank and extending into the river far enough to cover as wide a front of barges as it is intended to shelter. These spur-dikes are not continuous structures, but consist of a line of disconnected cribs filled with stone, and having intervening spaces usually as wide as the cribs themselves. The object of these openings is to give passage to the current so as to prevent shoals from forming under the lee of the cribs. The down-stream faces of the cribs are vertical, and the up-stream faces have a very gentle slope, so as to reduce as much as possible the shock of ice and drift.

Such structures at the upper end of every coal-landing would greatly reduce the danger from ice. The best possible ice-breaker would be one that could be put in place in the autumn and be removed in the spring. It would thus give protection when protection is needed, and would be out of the way at times when its tendency to form a shoal below it would be a decided objection. Such an ice-breaker is, however, yet to be devised.

Sheer-booms.—The United States river-monitors that lay so long at Mound City were protected from ice and drift by a sheer-boom of heavy iron-plated timbers that was attached to the shore at a point above the fleet, and extended down far enough to cover the boats to be protected by it. This system is free from the objection of causing deposits below it, and it seems worthy of serious consideration as a method of protecting steamboats and model barges. The shock of a field of ice against such a boom would be at once transmitted to the boats behind it, but it would be distributed over so great an area as to act rather as a push than as a blow. The injury to steamboats is usually caused by the impact of the corner of an ice-field against a small part of the hull that yields to the shock, and, by admitting water, causes the boat to sink. The same blow distributed over a wide surface of the same hull would be successfully resisted.

For coal boats and barges the ice-breakers are apparently better than sheer-booms, as they afford much more reliable means of fastening the fleet.

Harbor-boat.—A harbor-boat that could be relied upon to break up the harbor-ice whenever such a course was deemed advisable, would, at times, be very useful. Whether its occasional use would justify its constant expense is a question that is open to argument. The strongest

point against such a boat is the fact that the city of Saint Louis built one, and after a trial of a few seasons ordered it to be sold. In any event, the construction of ice-breakers and sheer-booms to protect either public or private landings in Cincinnati does not seem to be a proper work for the general government to undertake, and the purchase and management of a harbor-boat apparently falls into the same category.

Dike at Four-Mile Bar.—It has been strongly asserted by several Cincinnati coal-dealers that the government dike at Medoc, 18½ miles below the suspension-bridge, has done them considerable indirect injury, by causing ice-gorges to begin at that point, and then gradually back up into the harbor of Cincinnati, which thus becomes closed. They have suggested that if a similar, but slightly higher, dike were built at Four-Mile Bar, 10 miles above the suspension-bridge, it would cause the river to gorge at that point before it did at Medoc, and that the effect would be to hold back the running ice so that the Medoc gorge would not receive sufficient re-enforcements to enable it to extend back to Cincinnati.

The theory is plausible, and ought to be tested, for the reason that Four-Mile Bar is greatly in need of improvements by dikes, being one of the worst bars on the river, and one that has often been selected for improvement, but laid aside for lack of funds. Dikes at this point are a necessity of commerce, whether they hold back ice or not.

CONCLUSION.

In closing this report, it seems proper to add that the chief cause of the great expense of any ice-harbor at Cincinnati is due to the great oscillation in the river-surface. Three of the low areas which have been examined average 27 feet below the level of extreme high water, which fact, considered by itself, would seem to indicate that but a small depth of excavation would transform any one of them into a harbor of refuge; but when we learn that extreme high water at Cincinnati reads 64 feet on the gauge, and when we recall the fact that our preliminary investigation showed that we must excavate our harbors to a depth of 4 feet below the zero of this gauge, or to a depth of 68 feet below high-water mark, we readily perceive how a level of 27 feet below high water is compatible with an average excavation of 41 feet.

For the maps which accompany this report I am indebted to Mr. William Weston, assistant engineer, and to his assistant, Mr. L. Petitdidier. To the former I am also indebted for the preparation of the very complete statistics, the collection of which, from innumerable sources, required an unusual amount of patience, industry, and perseverance.

Respectfully submitted.

WILLIAM E. MERRILL,
Major of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

APPENDIX V.

ANNUAL REPORT OF MAJOR JARED A. SMITH, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1878.

UNITED STATES ENGINEER OFFICE,
Indianapolis, Ind., July 13, 1878.

GENERAL: Herewith I transmit my annual report of operations for improving Wabash River, Indiana, during the fiscal year ending June 30, 1878.

Very respectfully, your obedient servant,

JARED A. SMITH,
Major of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

IMPROVEMENT OF WABASH RIVER, INDIANA.

WARWICK'S RIPPLE.

On the 1st of July, 1877, the contract with Mr. M. W. Nolan, of Jeffersonville, Ind., for rock excavation at Warwick's Ripple was still outstanding. This contract was entered into on the 29th of May, 1875, for the purpose of deepening and otherwise improving the channel.

The work was to have been completed December 1, 1876, but as considerable difficulty had been encountered from high water, the contract had been extended until December 1, 1877.

During most of the summer of 1877 the stage of water was favorable for the work, but although repeated assurances were received from the contractor that the agreement would be fulfilled, no excavation was made or even attempted during the season.

After the close of the season an application was received for a further extension of the contract, which was refused.

On the 1st of December, 1877, the contractor was notified that the contract had expired, and that no amounts were due or could become due him under its terms.

Meanwhile the remains of the coffer-dam, which had been constructed to facilitate the excavation, formed one of the worst obstructions to navigation to be found in the river. During high stages of water, when steamers of any size could readily ascend the river, the presence of the coffer-dam could hardly be detected, while its projecting timbers, directly in the channel, gave additional danger because concealed.

For this reason all the timbers and material of the dam which could be found were removed in June, 1878, by the United States dredges Ohio and Oswego.

Any boats which can ascend the river as far as Warwick's Ripple can now pass that place without difficulty, and until other points below are so far improved as to admit a different class of steamers at low water, *no further work at this place* need be contemplated.

DAM ACROSS NEW HARMONY CUT-OFF.

On the 1st of July a small portion only of the materials had been procured for constructing a dam across the break which occurred the previous winter. This break was about 200 feet in width, and the water to an average depth of 16 feet was rushing through the break at a rate of 6 feet per second.

The island bank on one side of this chute was of sand and loam, which was constantly washing away, as it was but little better than a quick-sand.

Mr. Fr. Stein, assistant engineer, who had been previously in charge of the working parties, was relieved of that duty, and Mr. Charles B. Bateman was employed to succeed him.

Nearly the entire month of July was consumed in procuring the materials and appliances for prosecution of the work.

The small steamer Oil City was hired as a tow-boat, and several flat-boats and barges were procured. It was found necessary to go about fourteen miles up the river to Webb's Ferry to procure stone for filling cribs, and a party of quarrymen were at once set to work at that point and continued throughout the season.

It being remote from any town or dwelling, the men were furnished with accommodations for cooking and sleeping upon an old barge tied to the shore.

Timbers were purchased at various points along the river, and were cut, hauled to the banks, and taken in the flat-boats to the work.

On the 24th of July, cribs were begun for the protection of the island bank. These were constructed 15 feet square in plan, and as high as the depth of water where they were to be placed, an average of 17½ feet.

The cribs for the bank protection and dam were built of the most durable timber to be found in the vicinity. They were made with an open grillage bottom, and the logs were left unhewn, save flattening where timbers joined. The side and end courses were alternate, thus leaving open spaces of from 3 to 6 inches between courses.

The superstructure of the dam was built continuous. The timbers were secured together by ¾-inch drift-bolts of round iron, and each crib was anchored to the bottom by four 2-inch bolts extending through the bottom timbers and 18 inches into the rock.

The first crib was placed about 40 feet above the line of the upper side of the dam, and a continuous line 275 feet in length was formed of such cribs, placed on the rock bottom of the chute, as near as possible to the foot of the bank slope, and filled with stone.

The space behind these cribs was filled with stone and shale until a slope of 1 on 3 was formed from the inner line of the cribs to the top of the island.

Below the lower end of this line of cribs a riprap of stone was thrown against the bank, as high as the top of the cribs, a further distance of 100 feet, and the bank slope above was cut in the same plane as that behind the cribs.

The top of cribs and bank of slope below the dam, a distance of 300 feet in length and 50 feet wide, was carefully paved with flat stone set on edge and about 1 foot deep.

The break was then closed with a work of cribs, 20 feet in width, filled with stone.

The cribs were launched successively from the bank already described, placed in absolute contact with each other, and in a perfect line. So well was this accomplished that not an accident occurred and not a tim-

ber was lost. This was made remarkable from the fact that in the first construction of this work, by contract, with water considerably less rapid and less deep, the river was strewn with cribs and fragments for a distance of more than 25 miles, the losses being so great that the contractors refused to continue the work.

In order to prevent any possibility of a recurrence of a break through the island at the end of the dam, the work was carried into the bank a distance of 60 feet in the rear of the protecting cribs, and was built a few inches higher than the top of the island for a length of 110 feet.

A few of the cribs in the break were 30 feet high. From this point the top of the dam was carried in a slope to the top of the old work at the junction with the new.

The top of the old and new dam and a portion of the island about the end, making 3,000 square yards, were then paved in the same manner as the slope of bank.

An embankment of stone, shale, and earth, 12 feet wide on top, was placed against the upper side of the new work, and the embankment, which had been much washed and injured, was re-enforced to the same dimensions.

During October, November and December the water ran over the old work from 1 to 5 feet in depth almost continuously, and it was therefore found impracticable to strengthen the old work with a new line of cribs, as was contemplated, though some of the materials were procured.

The two auxiliary cribs for holding capstans, &c., had been constructed 20 feet square and 18 feet deep, and filled with stone in the channel above the dam.

The work as described was completed December 26. The materials used in the construction were 1,954 logs, making 35,002 linear feet of round timber, 5,184 cubic yards of stone, 10,000 cubic yards of stone, shale, and earth, 5,479 ¾-inch drift-bolts, making 11,200 pounds of iron.

This work was done by hired labor and open purchases, and is incomparably better than the other portion, which was done by contract, while its cost has not exceeded four-fifths of what it would have cost at the prices under which the contractors failed.

As several sloughs occur on the island, of such a nature as to render possible a cutting of new channels around and near the dam, these sloughs have been obstructed with dams of brush, stakes, and stones, a length of about 300 feet and about 20 feet in width by an average of 3 feet in height.

The small piece of ground owned by the United States, at the end of the old dam, having been washed away, the island embankment and end of dam is now upon private property, and it is possible the question of damages arising from the break and subsequent wash may arise, as well as the necessity for purchase by the government of another small area sufficient for controlling the approaches to the work.

Regarding the work of 1876, I take the following from the report of Mr. Charles B. Bateman, assistant engineer, made to me January 2, 1878:

EXTRACT FROM MR. BATEMAN'S REPORT.

* * * When in the early part of December the river had receded to below the top of the old work and all the work being almost completely tight, the water fell from below the dam to a level lower than at any previous time during the season, and the old part of the dam was laid bare to inspection.

The clumsy construction, large size of and numerous gaps between the timbers, great spaces between the cribs, and the small amount and careless packing of the stone contained in the cribs, gave rise to grave apprehensions as to the ability of that part of the work to withstand its share of the pressure through the winter's floods, or until the work of re-enforcing them can be resumed.

widened to 120 feet.

Plans were immediately made and approved for repairing th and strengthening the other parts as proposed in the autumn, winter weather and stage of water being unfavorable for work not begun until April and no cribs could be placed in the break u end of May.

During the month of June 96 feet of the break were closed with of cribs 20 feet wide and 9½ feet deep filled with stone, leaving a feet to be closed.

In order to hold the cribs in position until they could be filled iliary or anchor cribs, 18 by 20 feet and 10 feet deep, were place 150 feet above the break and filled with stone.

The difficulty of closing this gap may be estimated when it is ered that the water has been at no time less than 9 feet deep, rapid that, in rushing through the break, its surface falls 2½ feet width of the dam.

This work will now be pushed rapidly, and it is confidently e that the present summer will find it all completed in a thorough stantial manner.

WORK OF DREDGES.

For the purpose of removing certain obstructions in the river, ity was obtained to procure the loan of the United States dredg and Oswego, together with their scows and flat-boats, pertainin improvements of the Ohio River.

The steamer Is. Keefer was hired at a rate of $41 per day to dredges and scows; this price includes furnishing crew and supp steamer and coal for use on both the dredges.

A considerable amount of repairs were required for the dred scows before they could start for the work, and further repai completed while on the route.

The fleet, consisting of steamer, 2 dredges, 2 barges of coal, 1 b tools and implements, and 2 dump-scows, left Cincinnati Apri arrived at Kingdom Bar, near Grayville, Ill., the evening of Apr

Several snags were struck and removed while going up the ri

at most of the bars were formed by snags, and that the latter
vorst obstacles in the channel.
number of snags were therefore removed, and the effect upon
s in many cases already apparent.
dges also removed all that could be found of the cofer-dam
the failing contractor at Warwick's Ripple.
proportion of the time the river was so high that the dredges
work at all.
16th of June the dredges left for Cincinnati, to return to their
ties on the Ohio River.
J. Carpenter, assistant engineer, was in charge of the work.
nanagement has shown him to be thoroughly conversant with
, and has met my cordial approval.
t the report of work accomplished, as follows:

REPORT OF MR. E. J. CARPENTER, ASSISTANT ENGINEER.

UNITED STATES DREDGE OSWEGO, *Cincinnati, Ohio, July 1, 1875.*

I have the honor to submit the following report of operations of the dredges
ash River during the present season.
contemplated was the removal of snags from the channel between Grand
nd the Ohio River, removal of the cofer-dam and crib-work at Warwick's
dredging at the following places: Kingdom Bar, French Creek, Warner's
f Rebiere's Island, head of Turkey Island, Hodges Bar, Winkler's Towhead,
New Harmony Cut-off.
so proposed to complete the opening of the Little Chain Cut-off in case a
ne Little Chain should show this to be advisable.
king such repairs as were necessary the dredges left Cincinnati and pro-
Kingdom Bar on the Wabash. On the way several dangerous snags were
om the channel at the Little Chain and just below the Grand Chain.
he Kingdom Bar to be composed of an extremely light sand, so fine that it
y be held in the scows, but as the river was too high for any other work
were kept employed at this until the water became too deep for the spud
boats.
nation of the other bars where dredging was proposed showed that all were
f sand, and as but little good would have resulted from dredging where the
light and easily moved this part of the work was abandoned.
nel might be improved by a day or two of dredging at each of the bars
e, after the spring freshets had all passed and the river had begun to with-
water channel, but there was no time while the dredges were in the Wabash
ng out the bars would have done any good. In fact nothing more than a
improvement of the channel could be effected at any time by dredging.
wing is a statement of work accomplished by the dredges:

ar, sand excavation	2,731.0	cubic yards
y Island, sand excavation	[illegible]	cubic yards
k	3 snags,	24.0 tons
ar	3 snags,	14.0 tons
r	4 snags,	34.5 tons
	3 snags,	12.0 tons
id	11 snags,	73.0 tons
l	7 snags,	43.0 tons
	14 snags,	121.5 tons
ny	1 snag,	3.5 tons
re's Island	22 snags,	97.0 tons
y's Island	4 snags,	29.0 tons
y's Island	1 snag,	16.0 tons
Bar	1 snag,	1.0 ton.
tyrie's Bar	1 snag,	36.0 tons
Ripple	1 snag,	9.5 tons
l	3 snags,	35.6 tons
n	2 snags,	16.1 tons
sh	1 snag,	63.0 tons
	143 snags,	843.7 tons.

Ripple..... 181 crib and coffer dam timbers

One snag from Juno Bar, 1 from New Harmony, and most of those from h Rebiere's Island were placed in the New Harmony Cut-off.

At Warwick's Ripple all of the coffer-dam and cribs that could be found w moved.

After completing the removal of snags and the Warwick's Ripple obstructio dredges returned to Cincinnati.

While in the Wabash the dredges lost 4 weeks' working time from high wate fact, while they were in the river there was only about one week when the wat at a good working stage.

There was some time lost through accidents to the machinery, but not eno materially affect either the amount or cost of the work.

Very respectfully, your obedient servant,

E. J. CARPENTER, *Assistant Engi*

Maj. JARED A. SMITH,
Corps of Engineers, U. S. A.

GRAND CHAIN.

The only channel at this place which is navigable during low s of water is the one confined between dikes and forming a straigl about 2,000 feet in length and 100 feet broad.

The water rushes through this cut with great velocity. Its h situated just below a bend in the river, which throws much of the past it and between the east dike and shore.

This water is checked by ledges of rock near the foot of the cut is thrown across the dike into the chute, thus injuring the work producing side currents which add greatly to the already difficult gation.

It is also found that the bottom of the cut is not parallel to the surface, so that when 4 feet of water may be obtained at the foot chute but little more than half that amount will be found at its he

A party was set to work early in October, 1877, to remedy thes fects and to put the dikes in such condition that their surfaces wil be readily broken. Before any considerable amount of work coul accomplished autumn rains raised the river to such an extent compel its postponement until spring.

Not less than 1,000 cubic yards of stone was quarried from the adjacent and placed in the breaks of the dikes, thus repairing then

The surface of the new work was secured by a very carefully paving, covering a surface of 1,200 square yards.

Twenty oak posts were set at intervals of 200 feet along the east to aid steamers in "warping" through, as in many cases their own p would be insufficient. Heavy blows from drifting snags were too for the endurance of the posts, and they were all carried away durin winter. It is now proposed to obtain the same end by using heavy rings secured to the dike in such manner as to offer no obstacle t passing drift.

During the present season the upper end of the east dike will be nected with the shore by a work of cribs and stone.

The top of the entire dike will be paved, and the channel cut in a manner as to give a uniform depth. A special survey for this pu has already been made.

A party, as large as could conveniently work, was again start the work on the 3d of June, and is making good progress. The will be increased and the work pushed more rapidly as the water sides.

LITTLE CHAIN.

A careful observation and study of this place has been made d the year in order to ascertain, if possible, the best and cheapest m of making a good channel past the reef at this place.

The work mentioned in the last annual report was done in pursuance of plans adopted by the officer who had previously had charge of the improvements of this river. This plan was to divert sufficient water into and through the small channel which leaves the main river about ¼ of a mile above the reef and rejoins it at a distance of about 2 miles below. This is called the cut-off, as the distance is a trifle shorter than by the main channel.

In the summer of 1877 a complete survey was made of this cut-off, including examinations of the bottom and driving of sounding-rods to a depth of not less than 8 feet below the plane of low-water.

The bottom was found to be favorable for the cutting of a new channel by the action of the current.

The cut-off is about 2 miles in length and an average width of about 150 feet between banks which are heavily wooded with immense forest trees.

Although the cut-off was cleared of snags 2 or 3 years since, it is now again so full of them as to make its navigation more than hazardous.

In order to make the channel satisfactory, a large amount must be cut away from its head to make a suitable entrance for passing boats.

The head of the island would require a substantial protection to prevent the extreme cutting of its banks.

The constant caving in of the timbered banks would require continued care and expenditure for several years to keep the channel open. It can be readily seen that the nature of this work would be such that even an approximate estimate of its cost cannot be made.

In case of the failure of an annual appropriation for the work, a probable result would be serious injury to the main channel by its loss of water, while the cut-off would be choked with snags and rendered useless. For these reasons any further work in the cut-off was postponed until a careful survey of the reef in the main river could be completed. This survey was completed in June, 1878, and the field-work has been platted.

There has not yet been sufficient time to make a detailed estimate of the cost of the necessary rock excavations for making a good channel, but whatever is done will remain, and will be to that extent a permanent benefit, and it is not probable that its cost will be as great as the ultimate expense of attempting to turn the channel in another course.

It is therefore now proposed to make such excavations as are necessary in the reef, and to close the cut-off chute by means of a dam of piles, brush, and stone.

SURVEYS.

In July, 1877, a survey was made of the United States lands on both the west and east banks of the river at the Grand Rapids, near Mount Carmel, Ill. Stones were set to indicate the boundaries of the grounds. Each stone was about 4 feet long and 1 foot square, with the letters U. S. cut on the top.

The topographical survey was also made of the site of the old lock, where it has been proposed to locate a new one, and a hydrographic survey of the rapids and a small portion of the adjacent channel. The survey was made by Mr. Fr. Stein, assisted by O. Petitdidier. At that time there were no maps of any portion of the river which could be relied upon in making any plans for future improvements, or for estimates of cost. The scope of the work was therefore far more restricted than it would otherwise have been.

To remedy this it was deemed best to make a systematic and contin-

Lines of soundings were taken across the river at intervals of a
100 feet, placing them nearer in the shallow water or at points w
improvements would be likely to be required. A line of levels was
run the entire length to ascertain the declivity of the water surface.
character of the bottom was also noted. In the Little Chain Cut
steel rod was driven down, to a depth of 8 feet below low-water in nu
ous places, to ascertain whether the underlying rock would interfere
cutting a new channel by action of the current.

These surveys have been reduced and platted in the office, the c
on a scale of 100 feet to 1 inch, and the remainder on a scale of 20
to 1 inch.

The soundings have all been reduced to extreme low-water refe
by the following method:

As the party passed the water-gauge at the Saint Louis and Southe
ern Railroad Bridge, *en route* to begin the survey, its reading was n
and a man was detached from the party to allow him to float down t
camp, a distance of about 6 miles, in a skiff. On his arrival a temp
water-gauge was at once established, on the same reading as the s
ard. On changing camp a new gauge was established in a si
manner.

These temporary gauges were read three times each day, and com
sons were made with the daily record of the nearest standard g

The hydrographic work being taken at a low stage of water, the c
ences in the readings for slight fluctuations in the water-level were
slight, and the reductions were, therefore, reduced by the readin
the local gauge. This is believed to obtain as close an approxim
as can be secured by any simple method.

As the propriety of improving the navigation at Little Chain by
ing the channel became doubtful, a survey of the reef and main ch
was undertaken early in April, 1878; but before any substantial pro
had been made the water became so high as to render any progre
tirely impracticable. The party was, therefore, withdrawn until ea

educed and platted by Mr. Charles B. Bateman, assistant engineer in harge of the work at that place.

WATER-GAUGES.

The daily reading of water-gauges on the piers of bridges at Vincennes, Mount Carmel, and Grand Chain has been continued.

For convenience of reference most of the work has been platted in ydrographs.

These gauges have been divided to read in feet and tenths, the zero aving been placed in a position to indicate as nearly as possible the west water known.

This, at Grand Chain, is more than a foot lower than any readings hich have been made since the gauges were established; and the charts, eing reduced to this standard, will therefore show a maximum of unfaorable conditions.

LOCK AND DAM AT GRAND RAPIDS.

A careful observation of the navigation of the river during the year as failed to indicate a necessity for this work which would be at all ommensurate with its cost.

The navigation of the river during the last year has been quite extenive, and there are evidences of a substantial growth in the carrying of reights by water; but there is little or no demand for any through reights by this water-route. Frequent inquiries have been made of oth shippers and carriers without once finding an opinion that the lock s at present a necessity, and no communication of any kind favoring his work has reached this office.

It is therefore deemed most expedient to use the money appropriated or improving the river, by giving attention to those places where a resent demand exists, leaving the commencement of so expensive a ork as a lock and dam until the traffic seems to require it, or until a pecific appropriation shall be made for that purpose.

IMPROVEMENTS CONTEMPLATED.

It is proposed to complete the works already mentioned in the New Harmony Cut-off, the Grand Chain, and the Little Chain.

There are several places in the river where the channel is divided, hus reducing the flow and forming bars. The water will as far as posible be confined to a single channel by closing the smaller ones.

The bars with which the river abounds at low water are the result of arious causes, the principal ones being too great a width in which the vater can flow, and the presence of snags. Small jetties or wing-dams of iles, brush, and stone can be so used as to reduce the width and concenrate the flow. The removal of the snags will accomplish the double bject of freeing the channel from dangerous obstacles, and of increasng the draught of water.

In some places the river-banks are constantly being cut away upon ne or the other side. Large trees and amounts of earthy matter are hus thrown into the water, supplying both the cause and the material or new bars.

Near Grayville, Ill., this cutting has reached such an extent that unless soon checked the town and its railroad, which has taken large amounts of freight from the river, will be left a long distance inland.

In places like this the banks will be protected with a work of piles, rush, and stone.

It is proposed to extend the removal of snags to the portion of the river between Vincennes and Terre Haute, as well as the part below.

No definite project and estimate has thus far been submitted for the complete improvement of the Wabash River, nor does it seem practicable at present to submit such a project, for the reason that reliable surveys of the river, as yet, extend over too limited an extent.

COMMERCE.

The large crops of the past year have caused a considerable commerce to spring up on the river, the larger amount of freight being taken to and from railroads by small steamers and tow-boats with barges.

From the most reliable sources it has been estimated that the freights moved in this manner below Mount Carmel, in the past nine months, are about as follows, viz:

2,000,000 bushels of corn.
150,000 bushels of wheat.
40,000 barrels of flour and meal.
4,000,000 pounds of pork.

Besides a large miscellaneous freight, consisting of apples, potatoes, seeds, hoop-poles, staves, lumber, groceries, machinery, and miscellaneous supplies.

In addition to the foregoing, constant trips have been made by several small steamers running in connection with railroads above Vincennes.

The following tabulated statement, which is approximately complete, for the winter and spring of 1878, will indicate the amount of commerce:

Names of tow-boats or steamers.	No. of barges in tow.	No. of trips made.	Tonnage.	Draught of water, loaded.	Remarks.
Sam Roberts	3	2	2,700	7	From Ohio River.
Grand Lake	3	3	3,500	8	Do.
John W. Garrett	2	1	1,800	7½	Do.
Etna	2	3	1,000	5	Do.
J. S. Neal	2	2	1,600	6½	Do.
Nashville	....	2	600	6	Do.
Hotspur	2	2	1,000	4½	Do.
Robin	1	1	350	4	Do.
Hope	1	6	200	.....	Do.
Trout	....	.....	85	3	Regular trips between Shawneetown and Grayville.
Ada	1	.....	75	3	Regular trips to Saint Louis and S. E. R. R.
Wash Obenchain, daily	....	.....	.....	.....	New Harmony to V. and C. R. R.
H. M. Sweetzer	....	.....	150	.....	Regular trips on White River to E. and T. H. R. R.
Belgrade	....	127	89	3½	Vincennes and Terre Haute.
Russelville	....	.....	40	.....	Regular trips Russelville to Vincennes.
Antelope	....	.....	30	.....	Above Vincennes.
Prairie City	....	.....	100	.....	Do.
Billy Parsons	....	.....	20	.....	Do.

Money statement.

July 1, 1877, amount available	$85,679 61	
Amount appropriated by act approved June 18, 1878	50,000 00	
		$135,679 61
July 1, 1878, amount expended during fiscal year	37,701 90	
July 1, 1878, outstanding liabilities	6,372 78	
		44,074 68
July 1, 1878, amount available		91,604 93
Amount that can be profitably expended in fiscal year ending June 30, 1880.		50,000 00

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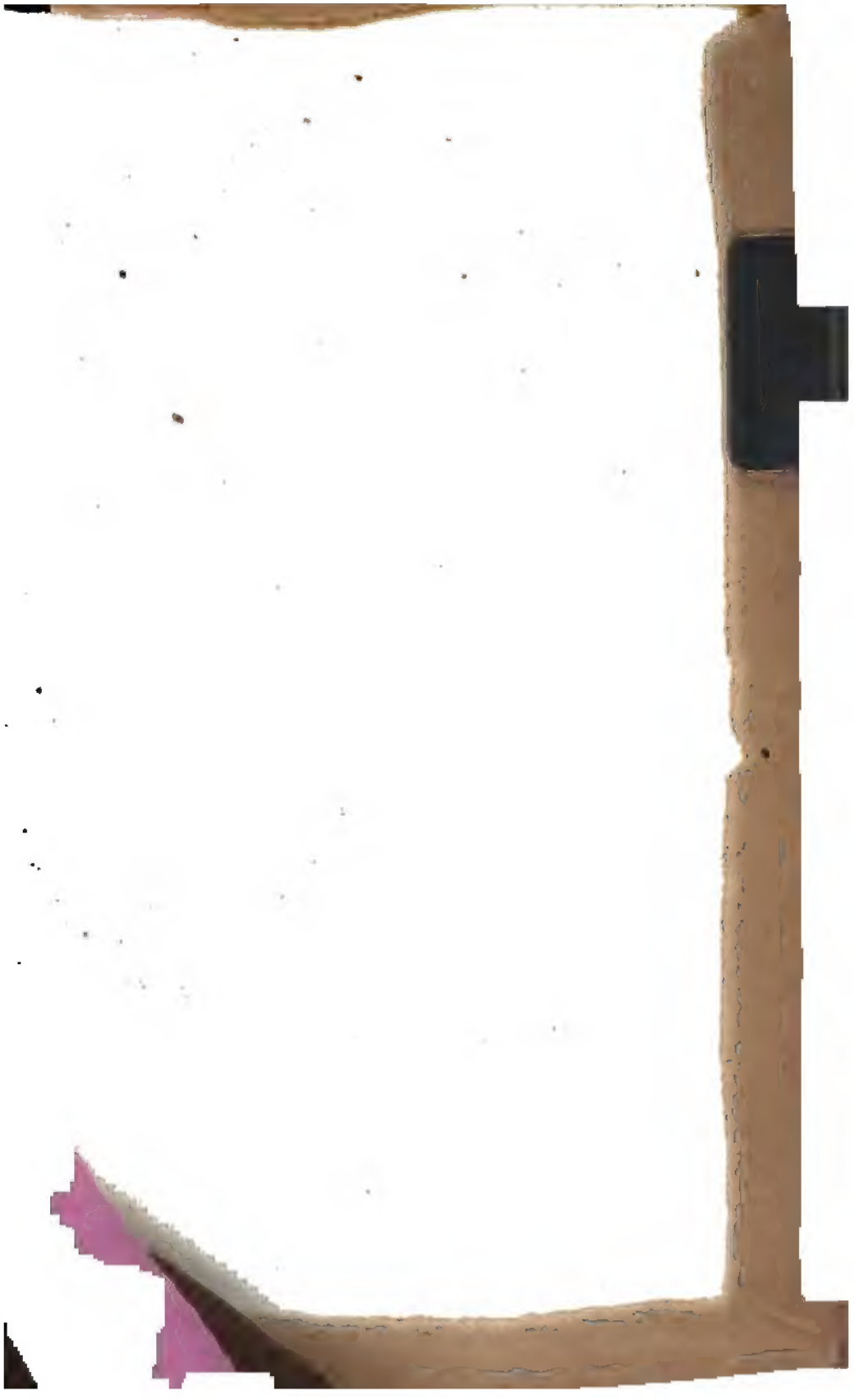
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